Historical Narrative

The 1970s

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THE SEVENTIES

58. <u>An Overview.</u> The 1970s was a tumultuous decade for the computer industry:

New technologies--monolithic semiconductors and very large scale integration, lasers, new magnetic recording techniques, advanced communications technologies and others--swept the industry.

Price cutting, new terms and conditions and new, cheaper products, with greater performance were announced in a "river of new product announcements", as one observer said. (DX 12265, p. 8.)

The meanings given to the term "minicomputer" in the 1960s disappeared as these products--called variously "minis", "maxis", "super minis"--were brought out with power and function equal to "mainframes", on a one-for-one basis and in groups or networks. (See pp. 1145-88 below.)

New types of components, products, software and systems were brought to market--microprocessors, "floppy" disks, ROMS, PROMS, mass storage devices, high-speed non-impact printers, "intelligent" terminals, distributed data processing and network processing capabilities--all of which taken together revolutionized the alternatives available to computer users.

Exits, consolidations or redirections by a few of the most prominent computer suppliers of the 1950s and 1960s occurred, such as by General Electric and RCA, and by a number of manufacturers of plug-compatible core memory who never made the shift to plug-compatible semiconductor memory. (See Andreini, Tr. 48581-85; DX 12135, pp. 29-31; for the GE and RCA stories, see pp. 488-618 above.)

Entry and expansion of newer competitors--many of whom didn't exist until 1969 or later--proceeded to the point where they became large, resourceful competitors that IBM and other long-established rivals had to reckon with and take into account in their development, product and pricing strategies.

What has emerged from the seventies is an industry no one could have imagined or did foresee in the 1950s. Significantly, there are more products, more alternatives, more computing capability and competing suppliers in numbers more vast than were conceived. And the industry as a whole, rather than producing a handful of machines to a handful of users, was, by 1979, an industry whose top 100 suppliers were, by some estimates, generating over 45 billion dollars in revenues worldwide. (DX 13945.)*

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* Datamation, a widely read trade periodical, has for several years published the results of its surveys of the top 50 U.S.-based companies in the data processing industry. In 1980, reporting on 1979, Datamation expanded its annual survey from 50 companies to 100 companies. (Id.; see p. 1068 below.)

In large measure the story of the Seventies for the computer industry lies in the growing diversity of suppliers and of the new and improved products and services they were compelled to introduce to attract and keep computer customers. This portion of our testimony will look first at the early years of the decade beginning with IBM's introduction of its System/370 and the actions of a number of other suppliers in those years. That is Part VI.

In Part VII, we review more fully the expansion and entry of some competitors, as reflected in the record of this case, from roughly the mid-years of the decade to the present.

Part VIII focuses again on IBM, specifically on what has been called a "flood of IBM announcements" (DX 12265, p. 8) in the second half of the decade, announcements marking IBM's various attempts either to catch up with other suppliers or to leapfrog them.

Part IX looks to the results of the competitive process--principally in the 1970s--as that process manifested itself in the alternatives that computer users actually have available to them and that they consider and implement in meeting their data processing tasks in "the most cost effective method". (Welch, Tr. 75501; see below, pp. 1338-40.)

Finally, in the Conclusion we review briefly some of the performance improvements in the industry over the past three decades.

VI. INTRODUCTION OF SYSTEM/370

59. Initial System/370 Announcements

a. Competitive Pressures: 1970. IBM's System/360, introduced in the middle 1960s and enhanced and augmented by new products and programming during the second half of the 1960s, was by any measure one of the most successful product lines in the history of American industry. As detailed in the 1960s portion of this testimony (pp. 367-75 above), deliveries of that line of equipment--in volumes unprecedented in the computer industry--transformed IBM into one of the largest and most successful companies in the world.

But by the end of the 1960s, IBM's position and growth in the industry had already been impacted heavily by its competitors, including:

(i) pricing actions and product line enhancements and improvements from systems manufacturers. (See above, pp. 473-749.)

(ii) rapid-fire introductions of "plug-compatible" peripheral equipment--particularly tape drives, disk drives and memory--from Memorex, Telex, Ampex and other companies. (See pp. 750-96 above.)

(iii) leasing companies which had acquired large volumes of IBM manufactured equipment from customers or directly from IBM and were marketing that equipment on a variety of terms and conditions against the equipment IBM's sales force was marketing. (See pp. 826-30 above.)

Hence, despite the overwhelming market acceptance of its System/360 line, IBM's U. S. EDP revenues had peaked in 1968 and remained essentially flat through 1972. (DX 3811.) Over the same period, as measured by Census II, the U. S. EDP revenues of IBM's competitors (who grew in number from 420 to 617) almost doubled. (DX 8224.)

Two other factors added to the competitive pressures on IBM at the beginning of the Seventies:

First, by January 1970, IBM was implementing its "unbundling" announcement of June 1969, in which IBM announced the separate pricing of certain support services. (See above, pp. 462-72.) Significantly, some of IBM's largest competitors did not "unbundle" at that time because they saw competitive opportunities in remaining "bundled". For example:

(i) McDonald of Sperry Univac testified that his company

> "felt it would be to our competitive advantage to maintain our previous pricing policy so that we could go to the customers, potential customers of IBM, and say to them that we would offer you these services which we have in the past under the same pricing policy, and you know what you will be getting from us, and under the IBM unbundled pricing policy, only time will tell what your real prices will be; and I think this was effective, at least for a period of time." (Tr. 2896.)

(ii) Spangle of Honeywell testified that his company initially chose not to unbundle following IBM's 1969 announcement because, among other reasons:

> "[W]e had hoped to gain some temporary market advantage and a way out of our infirmity because we thought there would be quite a bit of resistance to this change by the customers and prospects, and that because of that we might be able to get some customers that we otherwise would not have been able to get." (Tr. 5087.)

Second, beginning in late 1969, the country entered into a serious recession. According to a U. S. Department of Commerce Report published in August 1970, "[p]otential private purchasers, especially the electronics, aerospace, and automotive industries, are delaying orders or foregoing new EDP purchases in order to preserve their liquid assets, while Government procurement--especially Defense--is down for budgetary reasons". (DX 12135, p. 29.)

For a time, the growth in demand for EDP products and services slowed; users became extremely cost conscious: Currie of Xerox testified that "many computer users probably for the first general time in the history of the industry started reducing computer budgets instead of increasing them . . ." (Tr. 15334; see also Tr. 15334-36, 15344-45.) "The competition was very intense in 1970, all the computer manufacturers were impacted, and we were all struggling very hard for the business that was out there".

(Currie, Tr. 15340.) Rooney of RCA recalled that "[t]he economic situation for the computer business in 1970 was quite bad. As I recall, the shipments that year were down some 20 percent from the previous year." (Tr. 12264.) Many companies, such as CDC (DX 434, p. 3), DEC (DX 512, p. 1), Honeywell (DX 122, p. 6) and RCA (DX 653, p. 11) reported that the condition of the economy had had a direct impact on their business performance.

IBM was no exception. In its 1970 annual report, IBM management stated:

> "1970 was a difficult year for U. S. business as a whole. The condition of the economy affected our customers and, in turn, affected IBM. Data processing equipment previously installed with customers on a rental basis was discontinued at a higher rate than in 1969. But the substantially lower level of outright sales of computer products . . . was the primary factor which contributed to the decline in domestic operations during 1970." (PX 5767, p. 5; see also Cary, Tr. 101812-15, 101817.)

On the other hand, users' increased cost consciousness aided some suppliers. Guzy of Memorex testified that his company was "selling compatible products at a lower price and to the extent that users wanted to lower the cost of data processing during that period, it accelerated the rate at which these products were accepted, and our business was very good during that period." (Tr. 32537; see also Butters, Tr. 43719-20; G. Brown, Tr. 53169-70.) Similarly, Powers of IBM testified that 1970-71 was "a time when . . . customers were particularly interested in ways to save money. So that the lower price of the PCM equipment was . . . just that much more attractive in that particular time frame." (Tr. 95413.)

The leveling of demand and the user concern with cutting EDP costs added to the pressure for price reductions and heightened direct price competition among all suppliers of computer equipment and services, including IBM. That pressure became particularly visible when the Federal Government, the largest customer for computer products and services in the United States and the world, expanded its policies encouraging price competition among EDP suppliers. The Brooks Bill, passed by Congress in 1965, had given the GSA authority over the Federal Government's procurements of general purpose computer equipment and had given the Bureau of the Budget fiscal control over those procurements. (See above, pp. 870-77.) And as already discussed (see pp. 759-61 above), in early 1970, the Bureau of the Budget required all Federal agencies to consider peripheral equipment offered by independent peripheral manufacturers as well as peripheral equipment from systems manufacturers when cost savings could be achieved. (DX 5212; see also DX 4567; DX 5215; Wright, Tr. 13539-42.) In addition, in early 1971, the General Services Administration solicited proposals from over 300 suppliers for multi-year leases, with price discounts, for computer equipment. (DX 4381; Cary, Tr. 101671-73; see also DX 4355; DX 4567.)

b. <u>IBM's Initial System/370 Announcements.</u> IBM had begun the planning for its new systems or "NS" in the mid-1960s, even while the early System/360s were being shipped. (See pp. 878-79, 882-83 above.) IBM management was planning for a staggered announcement of NS processors beginning in the second half of 1969. (Cary, Tr. 101360-61.) Those dates slipped, in large part because IBM's "Merlin" disk storage system--then in development--encountered technical difficulties in development and was not ready for announcement. (PX 2474B, p. 1; Cary, Tr. 101361-62; see above, pp. 898-99, 917.)

Merlin was to be a major technological advance over the 2314, significantly faster and more reliable, and offering at least twice the storage density. (PX 2474B, p. 1.) Because IBM management considered Merlin to be critical to the competitive success of NS as a whole, the announcement of NS was delayed until Merlin was available. (Cary, Tr. 101361-62; PX 2468A, p. 2; PX 2474B, p. 1; see Case, Tr. 73733-34.) As Cary testified:

> "[T]he [System/370] 155 and the 165 are very, very high performance processors, but their performance characteristics couldn't really be utilized by a lot of customers unless they had a very high performance file available to use with them. . . ." (Tr. 101362.)

By June 1970 NS equipment--Merlin included--was ready and IBM began to announce the System/370 product line, starting with the largest processors in that line, the Models 165 and 155 (followed by the 145 and 135 in September 1970 and March 1971) and the Merlin disk file and its control unit, the IBM 3330 and 3830.

With the introduction of this new family of computer equipment, IBM began superseding its entire System/360 line. By 1970, it was evident that IBM's entire spectrum of computer products was under mounting competitive attack and that all its products--processors, memory, storage and input/output equipment--would be replaced within a few years' time with better performing lower priced equipment offered by its competitors, if not by IBM. As Evans put it,

> ". . . competitively speaking, the System 360 was out of gas" in late 1969. (DX 4740: Evans, Tr. (Telex) 3961-62.)

Withington also testified that if IBM had not come out with a computer system or series of computer systems comparable in price/ performance and functionality to the IBM System/370, "[o]ver time competitive products would have proved generally superior to those of IBM in price/performance and functionality and over time IBM would have proved unable to attract new customers and would have slowly begun to lose existing ones". (Tr. 56540.)

Although the introduction of new equipment with better price/performance could attract customers that would otherwise go to some other competitor, it was not without its costs. From IBM's perspective, the introduction of that newer equipment was likely to cause the return to IBM of highly profitable leased

System/360 equipment in a severe recessionary period in the United States. One might reasonably expect that IBM and other companies, in such a time, would attempt, wherever possible, to delay new product announcements that would have the effect of displacing their existing lease inventories and to avoid the marketing and other costs that must be incurred with the introduction of new product lines. Nevertheless, IBM could not sit back and wait out the '70-'71 recession. It introduced new products as rapidly as it could.*

The principal initial IBM System/370 announcements were these:

(i) Model 155 and 165 Processors. The 155 and 165 CPUs and their high performance channels were announced on June 30, 1970. Both processors were System/360 compatible and were hence capable of being used with existing System/360 peripheral equipment and software. (PX 4505, p. 1.)

The advantages of the 155 and 165 processors were largely in speed and memory capacity, which in turn permitted greater data and programming handling capabilities. The 155 processor used the

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*Due to continuing competition, IBM's "net sales record increase" (NSRI), an internal measure based on "point" value (PX 2896, p. 3) was negative in 1971, meaning that the volume, in points of monthly rental dollars, of equipment being returned to IBM was greater than the point value of orders for new equipment--despite the introduction of System/370. (Cary, Tr. 101462-65; Akers, Tr. 98023-24, see PX 6474, p. 4.)

"buffer" memory techniques first introduced in the industry by IBM with the Model 85 in 1968. (See E. Bloch, Tr. 91540-41.) It offered greatly improved internal speed: as much as 4 times that of the System/360 Model 50. (PX 4505, p. 1) The 155 also could accommodate up to two million bytes of main memory as compared with about 256 kilobytes on the Model 50--a nearly 8-fold increase in maximum memory capacity. The 370/155 Model H with a main memory of 256 kilobytes was priced only about 50 percent more than the 360/50 Model H, also with 256 kilobytes of main memory. Thus, the user was offered an improvement in terms of internal processing speed per dollar of over 150 percent. Even comparing the higher priced 370/155 Model J with one megabyte of memory to the 360/50 Model H (with 256 kilobytes) the improvement in internal processing speed per dollar was almost 90 percent.* (JX 38, p. 32; DX 912 A, p. 4; PX 4505, pp. 1, 3.)

The 370/165 processor offered up to 5 times faster internal processing speed than the 360/65. (PX 4505, p. 1.) The 370/165 Model J, with 1 megabyte of main memory, was priced only slightly higher than the 360/65 Model J, also with 1 megabyte

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* The prices compared are the purchase prices of each processor with the amount of main memory indicated along with any console or features necessary for the CPU to operate. These and similar subsequent comparisons do not take into account the fact that the purchasing power of the dollar dropped significantly between 1964-65 and 1970-72.

of memory. That offered the user an improvement in internal processing speed per dollar of over 350%. The higher priced 370/165 Model K with 2 megabytes of memory offered an improvement over the 360/65 Model J in internal processing speed per dollar of 280%. (PX 4505, pp. 5-6; JX 38, pp. 393-94.) The main memory capacity of the 165 extended up to three million bytes, as compared with 1 million bytes on the Model 65, a 3-fold improvement in the maximum memory capacity. Also, the price of the main memory dropped by two-thirds. (PX 4505, p. 6; JX 38, p. 394; see above, pp. 920-21.)

The 155 and 165 were not "virtual memory" processors; IBM's virtual memory systems control programming was not ready for announcement in 1970. (Case, Tr. 73754-56; PX 5628, p. 2; see pp. 916-18 above.) However, the 155 and 165, with some additional hardware, as well as the later announced 370 Model 145 and 135 processors as originally shipped (see p. 1049 below), were equipped to accept "virtual memory" control when the software became ready. (DX 1639; DX 1640; see also Case, Tr. 73754-56.)

(ii) <u>IBM 3330/3830 Disk Subsystem.</u> IBM's announcement level forecast assumptions for the 3330/3830 disk subsystem, (DX 7858), indicated that by 1970 many of IBM's system,* plug-compatible and leasing company** competitors had brought out

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* The analysis mentions: Burroughs, CDC, DEC, GE, Honeywell, NCR, RCA, SDS, UNIVAC. (<u>Id.</u>, p. 2.)

** The analysis also mentions: Century Data Systems/CalComp, Data Recording Instruments, Friden, GE, Hitachi, ISS, Linnel, Marshall, Memorex, Potter, Tracor-PGI, ICL, Talcott Leasing, Greyhound, Telex, Bryant, MAI. (<u>Id.</u>, p. 3.)

disk devices that were highly competitive with IBM's existing 2311 and 2314 products.

The 3330/3830 disk drive and control unit, as announced, represented a major technological and price/performance improvement over those existing disk subsystems. The 3330's data transfer rate was 2-1/2 times that of the 2314, and the storage capacity per disk spindle was more than 3 times greater. (DX 1437, p. 1.) The 3330's combination of a voice coil actuator and a new track following "servo" system was a major innovation. (Haughton, Tr. 94887-88; 94908-09.) Also, for the first time in the industry the disk drive control unit was programmable and contained sufficient processing and storage capability to permit the subsystem itself to execute extensive error detection and correction and to take over various control functions otherwise performed by the CPU and/or its channels. (JX 38, pp. 971, 974; DX 4106, Ice, pp. 78-80.) In addition, the 3830 control unit included IBM's innovation of a writeable control store consisting of a disk cartridge housed within the unit to load and store control and diagnostic programs. (JX 38, p. 973; PX 3664A, pp. 10, 14; DX 4106, Ice, p. 78.)

The 3330 was recognized by IBM's competitors and throughout the industry as an innovation of appreciable competitive importance. Rooney of RCA testified that the 3330 "brought to the users significantly improved price/performance, capability of storing and retrieving data on disks at much faster speeds than we had hitherto". (Tr. 12048-49.) In his opinion, the 3330/3830 was a significantly better disk drive and disk control system than any other manufacturer offered at the time (Tr. 12049); its announcement with the 370 family was felt to be "very significant, very profound, and would have a great impact on RCA . . . ." (Tr. 11939.) Beard of RCA similarly recalled that, with the 3330, "for roughly the same number of dollars . . . a customer would achieve about three times as much storage, and there was also a speed improvement in the neighborhood of 50 percent". (Tr. 9054-55.) Currie of Xerox stated, "I think when the 3330 disk drive was introduced by IBM it had a very valuable price/performance profile in the eyes of many users, and I am convinced that users selected IBM systems based on that device as a major factor". (Tr. 15495-96.) Withington also testified that the 3330 represented an advance in the state of the art. (Tr. 56250-51; see also Wright, Tr. 13131-33: "substantial advancement".)

(iii) IBM 3211 Printer. Together with the System/370 Model 155 and 165 processors and the 3330, IBM also announced a new high-speed printer, the 3211. This printer used improved versions of the "train" printing technologies of IBM's popular 1403 printers. (DX 1437; see above, pp. 320-23.) The 3211 was capable of printing 2,000 lines per minute, as compared to about 1,100 lines per minute for the 1403-N1 provided with System/360. Rooney of RCA testified that with the 3211, "You could print the reports at a much faster rate. Therefore, you could improve the overall throughput of the system"--"one of the ways to measure performance when you do a price/performance measurement". (Tr. 12059.)

(iv) IBM System/370 Model 145 Processor, the IFA and the 2319 Disk. In September 1970, IBM announced the System/370 Model 145 processor, the first processor in the computer industry to be offered with main memory made exclusively of the new monolithic semiconductor technology. (PX 4527; Rooney, Tr. 12049-50; Andreini, Tr. 48565; E. Bloch, Tr. 91542; Case, Tr. 72385-86.) The internal performance of the 370/145 was up to 5 times that of the System/360 Model 40, although the 370/145 Model H was priced only about 26% higher than the 360/40 Model H, both with 256 kilobytes of memory. Thus, the 370/145H offered an improvement in internal processing speed per dollar of almost 300 percent over the 360/40H. (PX 4527, pp. 2-3; JX 38, p. 32; DX 912 A, p. 4.) In addition, the 145 offered up to a half million bytes of main memory, while the Model 40 had a maximum capacity of a quarter million bytes of main memory. (JX 38, p. 32; PX 4527, pp. 2, 3; DX 912 A, p. 4.)

The use of monolithic semiconductor memory in the 370/145 also represented a significant technological step and was a direct result of IBM's earlier decision--with its attendant risks--to shift memory development away from magnetic core technology into semiconductor technologies. (See above, pp. 907-11; Andreini, Tr. 48451-55; E. Bloch, Tr. 91537-41; DX 1994, pp. 18-19.) Again, Rooney testified:

"[I]t set a target for us. We considered this a very significant improvement in the whole field of data processing and felt that we certainly had to have this ability in the future. I can't classify it as having an effect on RCA other than that they came out with what we considered to be a significant technological improvement." (Tr. 11923.)

The 145 could be used with the earlier announced 3330/3830 disk subsystem. But, with the 145 processor, IBM also announced a low-priced optional Integrated File Adapter (IFA) feature. The IFA consisted of disk control electronics which were integrated into the cabinet of the 145 processor and could control a maximum of eight 2314/2319 disk spindles (totaling 233 million bytes of storage); with that limit, the IFA eliminated the need for separate, more costly disk control units. (PX 4527, pp. 3-4; DX 4740: Evans, Tr. (Telex) 4023-25; Haughton, Tr. 95021-23; see above, pp. 905-06.) The IFA was priced at less than one-half the rental price of the control unit used with IBM's 2314 disk drives. (DX 4742, Kevill, pp. 522-24.) With the IFA, IBM also announced the 2319 drive, which was essentially a repackaged, price reduced, three disk spindle version of IBM's successful 2314 disk drive family. (Cary, Tr. 101370-71; see above, pp. 902-06.)

The benefits of this low cost disk system package were these:

While larger 145 processor-based systems could use the high performance IBM 3330 disk system--then unmatched by competition--IBM's announcement of the low cost 2319/IFA permitted IBM to offer smaller, less costly, "entry level" configurations of 145 systems to potential customers. (DX 4740: Evans, Tr. (Telex) 4010-11; PX 4138, p. 2.) IBM had been developing an innovative lower cost disk subsystem--the "Winchester"--since 1969 (Haughton, Tr. 94912-16; see pp. 902-06 above) but that program was not ready in 1970 and would not be ready for nearly three more years. (PX 4538.) IBM couldn't wait. By 1970, as the Merlin forecast (DX 7858) and other internal IBM memoranda acknowledged, a number of systems manufacturers were offering disk products that had equalled or exceeded the performance of IBM's 2314 disk subsystems--the products that had played such an important role in the success of 360. (See pp. 323-32 above.) Those companies included Univac (DX 4756A, p. 51), Honeywell (DX 4756B, pp. 30-32), CDC (G. Brown, Tr. 51068-71), RCA (Rooney, Tr. 12144), GE (DX 4756A, p. 19), SDS (DX 4756, p. 48), DEC (which purchased its drives from Memorex (Guzy, Tr. 33184)) and Burroughs. (PX 2644, p. 161.) In addition, the increasingly successful PCM competition was convincing IBM's customers to return IBM 2314 subsystems on System/360 "almost by the trainload" (DX 4740: Evans, Tr. (Telex) 4011) and they could certainly be expected to do the same when the 145 was marketed--unless IBM made some significant price or performance improvements.

Hence, the combination of the lower priced 2319 and the IFA would give IBM a competitive disk offering for smaller 145-based systems. (Powers, Tr. 95338-40; PX 2635A, p. R2) and at the same time would make IBM's disk products more competitive with the plug-compatible competition. (See DX 4740: Evans, Tr. (Telex) 4011; PX 4214; see also Page, Tr. 33107; Friedman, Tr. 50430-31.)

IBM expected to re-use returned 2314 disk drives and, with the addition of some new control electronics, to be able to offer the 2319 drives for about $1,000 per month for the three-spindle configuration. (Haughton, Tr. 95021-22; PX 4527, p. 2.)

(v) IBM 3420 Tape Subsystem. In November 1970, IBM introduced the "Aspen" tape subsystem, which consisted of the IBM 3420 Models 3, 5 and 7 tape drives and the 3803 control unit. (JX 38, pp. 981-83.) This new subsystem could be used with 360 as well as with the new 370 systems. IBM's announcement of this product came at a time when IBM was facing enormous competition in tape products, from plug-compatible equipment manufacturers and from systems vendors. During 1969 and 1970, over 20 companies announced a total of 30 to 40 tape systems, promising better price/performance than IBM's current tape product line.*

The new 3420/3803 subsystem gave IBM a lower priced tape offering and embodied significant innovations in reliability and performance. (See Beard, Tr. 9054; Aweida, Tr. 49170-71, 49380-401; DX 5155, Gruver, pp. 55-97A; DX 3098: Winger, Tr. (Telex) 5696-5716; see also DX 3119.**

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* See DX 4756A, pp. 2, 4, 11, 16, 27, 32, 55, 74, 80, 85, 86; DX 4756B, pp. 4, 5, 6, 10, 13, 17, 33, 34, 36, 41, 50, 57, 58, 101, 108, 115, 120, 121; PX 4033, pp. 28, 33; see also PX 5360.)

** Among the technological innovations and improvements in the 3420/3803 tape subsystem were: use of a "digital" interface between the drive and control unit (DX 2137, pp. 4-5; DX 5155, Gruver, pp. 68, 87-88, 91, 93; DX 3117, Dallenbach, p. 223; DX 7619: Winger, Tr. (Telex) 5700-03; Cooley, Tr. 31940-41); a ""radial" connection

As we have discussed (see above, pp. 890-98), the "Aspen" project had been under way within IBM for about 4 years under different code names. (See Aweida, Tr. 49617-22; Tr. 65492-94 (stipulation); DX 4740: Evans, Tr. (Telex) 4122-24.) One of the original goals of that program was a quadrupling of the recording densities on the magnetic tape. That goal which was not achieved until 1973. (See below, pp. 1054-55.)

(vi) IBM 2319B and Disk Price Reductions. In December 1970, IBM announced the 2319B disk drive. (JX 38, pp. 988-93; Whitcomb, Tr. 34313-14.) The original 2319, announced for use on the 370/145, was renamed the 2319A. The 2319B was not strictly speaking a "System/370" announcement. The 2319B drives were offered for attachment to System/360, although they were capable of being upgraded to 2319A drives in the field, and as such, could be used with System/370 systems equipped with IFAs, if users chose to install the newer IBM equipment. (JX 38, pp. 988-89; see also Powers, Tr. 96247-48.)

Like the original 2319, the 2319B product reused older 2314 disk spindles. (Cary, Tr. 101370-71.) With the 2319B IBM

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among tape drives in a string (DX 5155, Gruver, pp. 87-88; DX 7619: Winger, Tr. (Telex) 5700-17; Aweida, Tr. 49400); the use of monolithic circuitry (DX 4253, pp. 6-7; DX 5155, Gruver, pp. 25, 59-60, 65-66; DX 7619: Winger, Tr. (Telex) 5698); built-in programmable diagnostic capability (DX 7619: Winger, Tr. (Telex) 5696-97, 5766-67, 5706-08, DX 5155, Gruver, pp. 60-64, 73, 96-97); "amplitude sensing" for improved reliability in recording reading (DX 7619: Winger, Tr. (Telex) 5715-18); and improved rewind times. (DX 7619: Winger, Tr. (Telex) 5716-17; DX 4740: Evans, Tr. (Telex) 4135-37.)

offered its System/360 users the same price-reduced disk drives--as compared with 2314 drives--that IBM was offering to its System/370 users with the 2319A: a monthly rental price of roughly $1,000 for three disk spindles. (JX 38, pp. 988-92.)

Also in December 1970, IBM reduced its prices further on its disk storage products by eliminating "additional use" charges for IBM 2314, 2319 and 3330 disk drives. (Cary, Tr. 101371-72; PX 3147, p. 1.) Those charges had been made for additional hours of use above the number included in the basic rental contract for the equipment.

(vii) System/370 Model 135 Processor. In March 1971, IBM announced what was then the smallest "member" of the System/370 family: the Model 135 processor, which was compatible with System/360 programming and was capable of using System/360 and 370 peripheral equipment, including the 3330 and the 2319/IFA. (PX 4528, pp. 3-4.)

This processor was 2 to 4.5 times faster than the System/360 Model 30 and, for example, the 370/135 Model FE with 96 kilobytes of main memory was priced less than 50 percent above the 360/30 Model F with 62 kilobytes of memory. Thus, the 370/135 FE offered the user an improvement in internal processing speed per dollar of almost 220% over the 360/30F. Even the 370/135 Model DH with almost 4 times the main memory of the 360/30F offered an improvement in internal processing speed per dollar of over 100%. (See JX 38, p. 32; DX 912A, p. 3; PX 4528, pp. 2-3.) The 370/135's memory, like that on the 145 processor, was monolithic semiconductor rather than the older core memory technology. (Id.) Moreover, the 370/135 offered up to roughly 4 times the memory capacity available on the Model 30. (JX 38, pp. 32, 79; PX 4528; DX 912 A, p. 3.)

(viii) IBM 3270 Terminal Subsystem. In May 1971, IBM announced a new family of terminal subsystems, the IBM 3270, which included terminal displays and printers and controllers for the subsystem. (JX 38, pp. 1013-15.) The 3270 announcement was IBM's first major "CRT" or display terminal announcement since the IBM 2260 terminals were announced in 1965, a year after the IBM 360 line announcement. In those intervening years, display terminals had become an increasingly attractive alternative method for computer output and input: unlike computer room-bound printers, such as consoles and card readers, display terminal equipment could be located more closely to where data were created and could be used to enter and display or print data in human readable form directly to the ultimate user, rather than requiring those users to go to a computer room, deliver their card decks or pick up their computer printouts. A number of manufacturers had begun offering display terminal equipment for use in computer systems during the 1960s and early 1970s. (See DX 4885; DX 4555, p. 1; see also DX 4484, p. 3; pp. 778-80, 791-92, above.)

The new IBM 3270 display system could be used as part of System/360 or System/370 computer systems and could handle a variety of on-line information processing applications, including data base inquiry, data entry, transaction processing, on-line programming--either attached locally or via remote communications links. (JX 38, pp. 1013-20.)

The 3270 systems, however, were still essentially "dumb" terminals, in the sense that little, if any, processing and storage were performed in this peripheral equipment, rather than in the system's main processing and storage equipment. Hence, this terminal announcement may be looked upon as a continuation of a "centralized" approach to data processing where, in systems using the 3270, storage, control and processing remained largely in the other equipment. As we shall discuss, other suppliers in the computer industry, particularly Burroughs, Data 100 and Four Phase, in the late 1960s and early 1970s--were already introducing equipment capable of substantial "distributed" processing and storage. (See pp. 982-84, 1069-70, 1221, below.)

(ix) IBM's Fixed Term Plan. Also in May 1971, IBM announced an optional lease plan for several of its System/370 and System/360 peripheral products. The "Fixed Term Plan", or "FTP", eliminated any remaining extra shift usage charges and provided an 8 or 16 percent discount from IBM's monthly rental rates for customers who chose the plan's one or two year term leases. (PX 4592.)

Through the 1950s and 1960s IBM had only offered its computer equipment under either purchase contracts or rental agreements generally cancellable by customers on 30 days' notice. During the 1960s, however, IBM's competitors had begun offering longer term lease plans ranging from 1 year to 5, 7 or more years, with discounts, to computer customers. Those competitors included systems manufacturers, plug-compatible peripheral manufacturers and leasing companies. (See e.g., Spangle, Tr. 5219-20, 5556-57; Aweida, Tr. 49501-504; Spitters, Tr. 54432-33; Powers, Tr. 95413-14; Cary, Tr. 101667-69; DX 4355, pp. 21-26.) And, as noted, in the spring of 1971, the General Services Administration formally requested EDP companies to submit plans for firm multi-year leases for computer equipment at discounted prices. (See DX 4355; DX 4381; Cary, Tr. 101672-73.) Thus, IBM's largest customer was soliciting specific terms and conditions not then available from IBM but offered by most, if not all, of IBM's competitors. Also, according to Powers of IBM, by early 1971, IBM's other customers were becoming "quite vocal about their desires to have long-term leases". (Tr. 95420.)

Another significant impetus for introducing a fixed term lease plan with discounts was IBM's continuing losses to plug-compatible peripheral manufacturers and leasing companies, both of which were marketing PCM equipment, with those kinds of leases. (Cary, Tr. 101674-77, 101849-50; Powers, Tr. 95413-16.) For example:

(a) According to B. O. Evans, PCMs and leasing companies, as well as systems manufacturers, "were hitting us [IBM] hard" and, as a result "our lack of success in the economic marketplace was startling." "[T]he competition was taking us apart. . . ." (DX 4740; Evans, Tr. (Telex) 4005, 4045.)

(b) By early 1971, PCMs were replacing IBM 2314-type disk drives at the rate of over 1,000 spindles per month. At that rate, IBM's installations of 2314-type disk drives would have reached zero in about 30 months or by mid-1973. (Powers, Tr. 95824-26, 96041-42; PX 3158A; PX 3692A.)

(c) Frank Cary testified that, in the spring of 1971, IBM was "concerned about the rate at which the PCMs were impacting the 2314s and the 2319s and so on. So we were concerned about the installed tape drives and the installed files. . . ." (Tr. 101849.) He added, "[W]e were very much aware of the fact that we were the only people that did not have term lease plans, and so we were very interested in getting competitive, not just price/performance-wise, but in terms of the terms and conditions we were offering as well." (Tr. 101850.)

(d) In March 1971, F. G. Rodgers, President of IBM's Data Processing Division, reported to IBM top executives (Watson, Learson and Cary) on the previous month's marketing results, stating that IBM's persistently high rate of equipment discontinuance was "a reflection of the continuing low level of the economy, as well as the high impact of leasing companies, data servicers and OEM". (DX 8059.)

By May 1971, IBM forecasters projected that without a fixed term lease with rental rate reductions, by 1975, plug-compatible manufacturers would have replaced essentially all of IBM's 2314 and 2319 disk products and all but 12 percent of its new 3330 disk drives. (Powers, Tr. 95444-48, 95786-90, 96007-08, 96047-48; PX 6401; Cary, Tr. 101685, 101931-32.)

In that May, IBM announced FTP for its disks and tapes and their control units as well as for printers, data cells, magnetic drums and their controllers. (PX 4592; DX 4551.)

At the time of its announcement, IBM's top management expected FTP to increase IBM's revenues and profits from those products, cut expenses associated with remarketing and reconditioning returned equipment, and reduce losses to competition. (Cary, Tr. 101376-77, 101688-94; Powers, Tr. 95416-17, 95426-36, 95440-42, 95449-50, 95458-59, 95462-68, 95530-31; DX 9380; DX 9381; DX 9382; DX 9383; DX 9390.)*

When IBM's top management decided to introduce the company's first term lease plan in 1971 on the products we listed, it expected that term leases of some kind would ultimately be offered with all the company's data processing products. (Powers, Tr. 95424; see also Cary, Tr. 101377-78, 101673-77) And, in fact, IBM later

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* Of course, FTP resulted in significant savings to users as well. If IBM's customers who took advantage of FTP had instead paid IBM at its monthly rates, those customers would have spent, during 1971 through 1977, an estimated $450 million more than they actually did. Users also benefited from the 15% purchase price reduction that was announced at the same time as FTP. (Powers, Tr. 95549, 95552-53; DX 9388.)

offered such lease plans for virtually every computer product it markets. (Powers, Tr. 95424; Akers, Tr. 96930-32; Cary, Tr. 101694.)

On the same day FTP was announced, May 27, 1971, IBM also announced "[p]urchase price decreases of approximately 15%, effective June 1, 1971 . . . for most disk, tape and printer products, [and] their associated control units. . . ." (PX 4593, p. 1.) Among those products were the 3330/3830 disk subsystem, 3211 printer, 2314, 2319A and 2319B disks, and the 3420/3803 tape subsystem. (Id., p. 3.)

In the months following IBM's announcement, competitors--including systems manufacturers, leasing companies and independent peripheral equipment manufacturers--responded with more price or product actions. (See Conrad, Tr. 13936-38; Cohen, Tr. 14645-46, 14654-57; Friedman, Tr. 50443-44; DX 977, p. 1; see also DX 1911.) Cohen of Xerox, for example, testified that "XDS reduced its lease and purchase prices on its disk drives in a very substantial way" after IBM's FTP announcement (Tr. 14645) and wrote in November 1971 that

> "other mainframe manufacturers (Honeywell, CDC, Univac, etc.) have followed suit with similar price cutting". (DX 977, p. 1.)

A year later, in June 1972, an industry observer--the International Data Corporation--stated in a Business Week "Report to Management":

> "Independents can replace half or more of the equipment associated with an IBM computer plus a growing percentage of the gear--especially communications oriented products--used with any computer. . . .

"As the independent peripheral manufacturers strive to fill their potential and the mainframe companies react to hold onto their own business, prices will come down as product performance and variety improve. And that's a bonanza from the user's point of view, since he wins in both cases." (DX 3132, pp. 2,4.)

60. Product and Pricing Actions of Competitors. During the years IBM was beginning to introduce its 370 line, other suppliers in the computer industry were doing the same with their product and services offerings. We will consider briefly computer systems manufacturers, plug-compatible equipment manufacturers and leasing companies.

61. Computer Systems Manufacturers. A number of computer systems manufacturers introduced new computer lines of their own and also reduced prices or enhanced the performance of their existing lines in the early 1970s. For example:

a. Burroughs. In October 1970, four months after IBM's System/370 Model 155 and 165 announcements and less than a month after IBM's 370/145 announcement, Burroughs formally announced a new family of computers, the "700 Systems", including the B 5700, B 6700 and B 7700 series--all of which included "monolithic integrated circuitry". (DX 10716, pp. 2-3, 11.)* Of the B 6700 in particular, Withington stated in February 1973 that it was the "[m]ost promising" of Burroughs' new models: "After years of difficulty in perfecting the software and hardware for the large computers, Burroughs now seems to have a perfected product". (PX 4839, p. 21.)

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* There is some indication that Burroughs, like CDC with its 6600 (see pp. 352, 406 above), may have discussed the 6700 with customers before announcement since Jones of Southern Railway considered that computer in 1969. (See pp. 1440-41 below.)

As part of the initial 700 System announcement, Burroughs also introduced new disk subsystems, including an IBM 3330-type, to be manufactured by Century Data Systems. (See PX 2606, p. 166; PX 2644, p. 160; DX 10716, p. 12.)

Some months later, in October 1971, Burroughs added the B 4700 to its 700 "family" and, in June 1972, announced the lower cost, lower performance B 1700. (DX 10265, pp. 18, 20.) B 1700 systems were marketed as replacement products for, among others, IBM System/ 360 Model 20 and System/3 computer systems. (PX 4966, pp. 2-3.) IBM's own new low-end System/370 processor, the System/370 Model 115, was not announced until the following year, March 1973. (PX 4537.)

In the fall of 1970, at approximately the same time as Burroughs' original 700 System announcement, Burroughs also introduced new processors in its Series L "minicomputer" line, originally introduced in early 1969. (DX 10716, p. 14; see pp. 652-53 above.) Burroughs described its Series L line in 1970 as "advanced, self-contained systems designed to handle the multitude of medium-sized data processing tasks which face most businesses". (DX 10716, p. 14.) The Series was, according to Burroughs' Chairman, a "COBOL machine" and represented product offerings from Burroughs "to respond to the needs of users, either an individual user that is a relatively small company, or small operation, or the small operation of a large organization". (Macdonald, Tr. 6914, 6892-93.) The 1970 announcement of one of the new "L" series machines, the

L 5000, included "48 standard applicational programs . . . for such areas as manufacturing, contracting, finance, hospitals and government". (DX 10716, p. 14.)

During 1971 and 1972, Burroughs announced larger, more advanced members of the Series L line: the L 7000 and L 8000 series, which offered up to 40 times the processing speed of the earlier Series L computers. (DX 3269, pp. 3, 14; DX 10265, p. 22; DX 3292-A, pp. 10, 15; DX 10722, p. 2.)

In a "common development program" with the L Series, Burroughs also continued to develop its intelligent terminal products, the Series TC "terminal computers", first introduced in 1967. (DX 10716, pp. 13-14; see also DX 10721, p. 10.) In 1970, Burroughs described these products as:

> "one of the most successful product families Burroughs has ever introduced. They are designed to operate as remote data communications terminals functioning on-line to a central computer system, or as self-contained, off-line systems." (DX 10716, p. 13.)

Those terminal products contained a significant amount of processing and storage capability. (See DX 10264, pp. 14, 18; DX 10285, p. 5; DX 10289, p. 9; DX 10721, p. 10; DX 10722, p. 1.) In 1970, two new models of the Series TC line were introduced, "increas[ing] the extensive number of applications which can be handled by the TC family of terminal computers". (DX 10716, p. 13.) John L. Jones of Southern Railway underscored the significance of the Burroughs "TC" line, which he installed in 1970, in this way:

"I wanted to point out for the Court that this equipment was installed in 1970, and that, to my knowledge at least particularly on Southern Railway Company, was one of the first times that processing began to migrate, I will say, out of the main processor into the peripheral devices. For example, because of the programmable nature of the Burroughs TC 500, there were certain formats and edits which had been made and checks previously in the main processor, which we now took and moved and put in the Burroughs TC 500 itself.

"That made eminent good sense, because now, as the operator was keying to that device, if an error was made of a type of the changes that we had made, the device itself, the processor in the TC 500 itself, would stop the operator and indicate the nature of the error immediately, but long before in the prior system the data would have had to go through the central processor, be checked, and then sent back again.

"So I wanted to point out this was the start of the concept of the distributed process in Southern Railway Company. . . ." (Tr. 79062-63; see pp. 1442-44 below.)

In 1971, Burroughs' corporate growth in revenues and earnings slowed, reportedly because of "soft economic conditions in the U.S. and some overseas countries". (DX 3269, p. 2.) In 1972, however, Burroughs' worldwide corporate revenues increased to just over $1 billion for the first time in the corporation's history; according to the company: "Electronic data processing systems and products, including business mini-computers, showed the fastest growth, increasing 28 percent over 1971". (DX 10265, p. 3.) The company's U.S. EDP revenues in 1972 were over $471 million. (DX 8224, p. 1.) By year-end 1973, Burroughs' worldwide revenues were almost $1.3 billion, while its new orders of "electronic data processing systems and products, including business mini-computers", increased another 27 percent in 1973. (DX 3292-A, p. 2.)

In those years, Burroughs' management was keenly aware of the technological pace of the computer industry. In 1972, Macdonald, Burroughs' Chief Executive Officer, stated that the "data processing equipment industry . . . has become synonymous with rapid and far-reaching change" (DX 426, p. 1):

> "In recent years, this rate of technical innovation has accelerated rapidly and has had the effect of significantly shortening active product life cycles, from as high as 40 years and more, to 20 years, to today's three to five years, with some as short as six to 12 months. In general, for large and very complex products we now aim at a product life cycle of about five years." (Id., p. 4.)

Mr. Macdonald also made this observation:

> "All segments of the total industry are made up of very dynamic, high-technology companies, and all have contributed to our very rapid rate of technological change. These companies vary in size from the leading independent mainframe manufacturers with annual revenues in the billion dollar range, to a great number of supplier companies with revenues from $50 million to $100 million, and to an even larger number of companies with smaller revenues." (Id., p. 15.)

He added that there were "more than 400" peripheral companies in the U.S. alone and "some 1,100" software companies. (Id.)

b. Control Data. CDC was one of the spectacular success stories of the 1950s and 1960s. (See pp. 241-51, 670-90 above.) In 1970, CDC was in the process of making initial shipments of several of its newer processors, including the CDC 6700 and 6200. (JX 24; see also DX 5861, p. 1.) In the early seventies, CDC also announced more new products and continued to expand the range of its EDP business. For example:

(i) In September 1970, CDC announced the development of the Star 100, which CDC claimed could handle 100 million instructions per second. (PX 355, p. 37.)*

(ii) In March 1971, CDC announced a new family of computers, the Cyber 70 Series. The Cyber 70 offered price/performance improvements over CDC's existing products, including the 6200, 6400, 6600 and 7600 computer systems, marketed "for solving a broad range of industrial, financial and institutional problems" and applications. (PX 355, p. 38; PX 6170 (DX 14511), p. 3.) As of 1972, Withington noted that the Cyber 70 Series was "selling well" and accounted for "the bulk of [CDC's] current shipments". (PX 4839, p. 23.) Norris, CDC's Chief Executive Officer, testified that a substantial portion of the Cybers delivered from 1972 and thereafter were delivered to new CDC customers who had previously used the EDP equipment of other manufacturers. (Tr. 6076-77; JX 24.)

In addition, CDC began marketing IBM plug-compatible peripheral equipment directly to end-users of IBM systems during the early 1970s--both 2314 and 3330-type disk subsystems.

As already discussed, by 1970, CDC had become quite active

* At the time of Norris' testimony in 1975, CDC had only delivered three Star 100 systems. (Norris, Tr. 5893.) In its 1974 Annual Report, CDC announced that management had taken charges against earnings as a result of the Star program. (DX 306, pp. 1, 5.) It also did not meet performance or schedule expectations. (Hart, Tr. 80307, 80315.)

in the OEM peripherals business (see pp. 682-84 above), and manufactured peripheral equipment not only for its own systems but also for sale on an "OEM" basis to as many as 150 customers. (Norris, Tr. 6021-30; G. Brown, Tr. 51002; DX 297; see also DX 4288, p. 3.) DX 297 is a "partial list" of CDC's OEM customers in the 1968-1975 time frame. (Norris, Tr. 6021.) According to Withington, in 1972, CDC remained probably the largest OEM supplier of peripherals products to computer system manufacturers. (PX 4839, p. 24.)

Beginning in 1970, CDC added to those activities the marketing of IBM plug-compatible peripheral devices. Its first major offering was the "23141" disk subsystem, designed as a plug-compatible replacement for IBM's 2314; the 23141 was marketed directly to IBM end users by CDC. (G. Brown, Tr. 51008-09, 51095; PX 4762, p. 3.) In early 1971, CDC also entered into an agreement with Telex to manufacture 3330-type disk drives, which Telex would market with its control units to IBM end-users. (See pp. 1005 below.) Also, CDC began marketing IBM-compatible add-on memory manufactured by Fabri-Tek. (Tr. 51008-09, 51486-89.)

Following IBM's FTP announcement in May 1971, CDC announced a variety of new lease options to users both of CDC's own EDP equipment and of its IBM plug-compatible equipment lines. (G. Brown, Tr. 51108-09, 51380-85; DX 295, pp. 2-3.) Gordon Brown of CDC testified that CDC was:

"forced to analyze the leases that we were offering to the IBM systems user and this led [CDC] to revise [its] own leasing policy and introduce a plan that [CDC] called the 3-1 Lease Plan. . . . [I]n other words, [CDC] countered that two-year lease plan of IBM with [CDC's] own three-year lease offering, a 15% reduction.

"We felt this was necessary to remain competitive." (Tr. 52598.)

In 1971 CDC announced a "double density" 2314-type disk subsystem. CDC marketed this product both on a plug-compatible basis as the 23122 to users of IBM computer systems and on an OEM basis as the 9742 to such customers as Siemens, ICL, CII, XDS, and Telex. (G. Brown, Tr. 51003, 51008-09, 51079-84, 51096; PX 4753, p. 2.) Gordon Brown explained why CDC developed the double density 2314-type disk and the success of the product:

"We envisioned a very large market, both in the OEM area and in the IBM plug compatible area. We viewed this effort as primarily an enhancement to the 2314 type of drive and felt that it would be very attractive and very marketable if it was properly designed and proved to be reliable in operation. And this indeed was the case. It was sold in large quantities OEM-wise and proved to be highly successful as a plug compatible offering to users who were still committed to a 2314 type of subsystem." (Tr. 51083-84.)

CDC encountered some problems, however, with its new IBM plug-compatible business. Although there was good market acceptance for the 23141 subsystem (PX 4762, p. 3), profitability was reduced because "[q]uite honestly, Control Data was late to market" the product. (G. Brown, Tr. 51009.) Also, CDC's initial 3330-type drives were unacceptable to Telex and their OEM deal was cancelled (see pp. 1005-06 below) and CDC experienced "a fairly high degree of problems" with the Fabri-Tek supplied memory for attachment to System/360 Models 50 and 65. (G. Brown, Tr. 52616-23.)

In 1972-73, however, CDC made a corporate decision to expand its IBM plug-compatible peripherals product lines. (G. Brown, Tr. 51003, 51164-65, 51459.) Hence, in 1973, CDC announced new IBM plug-compatible disk and tape subsystems (Brown, Tr. 52048-62, 52084-89; DX 2373A, DX 2375), and began to market IBM plug-compatible semiconductor memory equipment, this time manufactured principally by AMS. (G. Brown, Tr. 51456-58.)

From a financial viewpoint, CDC's computer business ended years of outstanding growth with a recorded $46 million loss in 1970 (DX 306, p. 20), said to be "due to poor computer business operating results and to year-end adjustments and write-offs in the computer business". (DX 435, p. 1.) By 1972, however, CDC's business returned to a profitable course. (DX 306, pp. 7, 20.)

c. Digital Equipment. By 1970, DEC had grown to a company of over $130 million in revenues and was manufacturing several lines of computer systems. (See pp. 722-32; 735 above.)

In January 1970, DEC introduced a new family of computers, the PDP 11. Two models were announced: the 11/15 and 11/20. Within six months, DEC had received over 500 orders (DX 511, pp. 2, 8), and by August 1971, had installed more than 1,200 PDP 11 systems world-wide. (DX 512, p. 1.) DEC enhanced the line in late 1970, and throughout 1971 and later, adding processors (including the 11/10, 11/40 and 11/45), peripherals and software and then cutting prices in 1972. (DX 510, pp. 6, 11; DX 512, pp. 1, 4, 5; DX 514, pp. 6, 8, 12.) Also in 1972, DEC announced a version of the PDP 11, the

"Datasystem 500", with a "separate type of packag[ing]" for business data processing. (See pp. 730 above.)

The PDP 11 family including, in those years, the PDP 11/45, could be configured into systems which were offered in competition with products ranging from the IBM 1130, System/3 and System/7 systems, to the "lower numbered members of the 360 and 370 series", which DEC "looked at" in pricing these products. (Hindle, Tr. 7354-55; PX 377-A.) The range of "representative applications" for the PDP 11 family of systems included "Business Data Processing", "Real Time Data Collection & Instructional Computing", "Industrial Control", "Commercial Typesetting" and "Data Communications". (PX 377-A.) The larger PDP 11 systems, such as the 11/40 and 11/45, were marketed in competition with IBM's System/360 and 370 systems, both as one-for-one competitive alternatives, and in configurations also including DEC's larger PDP 10 equipment, announced in the 1960s. (PX 377-A; Hindle, Tr. 7430; see p. 727 above.) In those larger systems, the PDP 11 might function as an intelligent terminal, giving users remote from the central computer installation substantial local processing capability. (Hindle, Tr. 7430.) DEC's 1973 Annual Report stated: "The PDP 11/45 has proven popular with end-users as an alternative to large-scale computers". (DX 510, p. 6.)

Also in the early 1970s, DEC continued to enhance its successful PDP 8 line, first introduced in 1964. (Hindle, Tr. 7332; see pp. 722-27.) Those enhancements included the announcement of the "Datasystem 300", for "business data processing". (See pp. 725-26 above.)

Hence, in the opening years of the seventies, the PDP 8 line was being marketed to "a wider variety of customers", including "communications customers, business data processing customers, newspaper typesetting customers". (Hindle, Tr. 7332.) The PDP 8 computers were offered in competition with a variety of IBM equipment, including the System/3 and IBM 360 and 370 systems. (Hindle, Tr. 7439, 7442; PX 377-A.)

Then in September 1971, DEC announced large-scale systems called the DECsystem 10. It announced five DECsystem 10 processors with configurations ranging in purchase price from roughly $390,000 to $2 million. The systems were, according to an IBM analysis sent to IBM's President, Frank Cary, and to John Opel, IBM's Senior Vice President, direct competitors of the IBM System/370 Models 135 through the Model 165. (DX 9406, p. 4; DX 514, pp. 6, 10.) The DECsystem 10 was based on DEC's PDP 10 processor. (See pp. 728-29 above.) The COBOL programming language and certain additional peripheral equipment and software, enhancing the system's batch processing capabilities, were added to the PDP 10 "to make it more successful in the business data processing marketplace". (Hindle, Tr. 7360, 7420-21.) DEC adopted the "DECsystem 10" nomenclature in order to give the machines a new "marketing emphasis". (Hindle, Tr. 7419-20.)

At the time of the DECsystem 10 announcement, Cary wrote to John Opel:

> "I think this is a very significant announcement. The selective marketing, accompanied by essentially an equity marketing approach to the customer, as well as a more economical development program for operating systems, makes DEC a major competitor in my book." (DX 9406, p. 1, emphasis in original.)

In 1971, DEC's worldwide revenues rose "modest[ly]" to almost $147 million from roughly $135 million in 1970. DEC's management attributed the company's "modest" performance to the "condition of the general economy". (DX 512, p. 1.) In 1972, DEC "posted increased sales and earnings . . . despite the slow recovery of the national economy"; its worldwide revenues were up to $187.5 million. (DX 514, p. 6.) DEC's domestic EDP revenues in that year were about $140 million. (DX 8224, p. 142.)

d. Honeywell. During 1970, Honeywell announced and completed its acquisition of a large part of General Electric's worldwide computer manufacturing and marketing organizations. (See pp. 542-46 above.) For the full year 1970, Honeywell Information Systems (HIS), the company's major computer subsidiary, had revenues of $859 million, which represented a 13% increase over the combined data processing revenues of General Electric and Honeywell in the preceding year. (DX 122, p. 33.)

In its 1970 annual report, Honeywell emphasized that: "The most significant event of the year was the successful merger of General Electric's computer business into Honeywell, giving us growth in this fast-moving field that otherwise would have required at least five years." (Id., p. 6.) In 1973, James Binger, then Chairman of Honeywell, echoed those views, saying that the Honeywell/General Electric merger may have been:

> "the most significant milestone in Honeywell's history, and it also is regarded as one of the largest business mergers ever transacted.
>
> "The result of the merger was to substantially increase the total size of Honeywell, double the size of Honeywell's computer business and establish Honeywell firmly in second place in the worldwide marketplace for computers." (DX 130, p. 14.)

In the first years of the seventies, Honeywell appeared to have lost little time in bringing out new products.

In February 1971, within months of IBM's, Burroughs' and others' announcements, HIS announced the 6000 Series, a family of systems with six different processors, offering improved performance over the older GE 600 line and improved peripherals, including newer disk subsystems of the IBM 3330 and 2319-type, tape subsystems, communications controllers and display terminals. (Binger, Tr. 4586-87; DX 163, p. 34; DX 14409, p. 1.) The Series 6000 utilized General Electric's existing operating system software (GECOS), developed originally for the GE 600 family. (Weil, Tr. 7217-18; Withington, Tr. 56140, 56149.) Orders for the 6000 Series quickly "exceeded [Honeywell's] expectations", according to the company's annual report. (DX 163, p. 34.) According to the company, "significant new customers" were won in the U.S. Government for the 6000 Series, with over 45 systems shipped or ordered in 1972-1973; the H6000 "continues to be one of the most successful computer series ever marketed by Honeywell". During 1972, "the main memory capacity of these systems was quadrupled in order to meet the growing needs of large system users". (DX 10031, p. 32.)

Then in January 1972, Honeywell introduced a second major new product line, the 2000 Series to replace its older H200 Series, which had been so successful in the 1960s. (See pp. 619-26.)

Honeywell management recognized the competitive need for these improved price/performance computers. Later that year, in October 1972, Mr. Patton, Vice President of Western Operations at Honeywell (Binger, Tr. 4682-83), wrote:

> "Generally, our overall image continues to be strong; however, as our competitors such as Burroughs and IBM continue to announce fourth generation concepts in their new equipment and software, i.e., 1700 virtual memory, 370/125, our customers and prospects are beginning to ask when is Honeywell going to announce its new product line. . . . We definitely require the 2020 and 2030 if we are going to continue our new name penetration at that level." (DX 127, p. 1.)

The 2000 Series was a family of systems which offered "advanced performance capabilities in data communications and data base management". (DX 163, p. 34.) Included in the 2000 Series announcement was the introduction of a new, programmable communications processor, the DATANET 2000.* According to Honeywell:

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* IBM's programmable communications controller, the IBM 3705, was announced a few months later, in March 1972. (See pp. 1043-45 below.)

"An advantage of the Series 2000 is an advanced data communications controller, the DATANET 2000. It manages the transmitting and processing of data in the 2000 System arriving from many locations at frequent intervals. More than 12 per cent of Series 2000 orders worldwide include this important new subsystem, illustrating the growing significance of data communications to medium-scale computer users. The heart of the DATANET 2000 is a minicomputer developed and produced at our Framingham, Massachusetts facilities." (DX 10031, p. 32.)

As to the 2000 Series equipment as a whole, Honeywell reported in 1973 that its shipments "were at record levels", including large orders at Ford Motor Company, the U.S. Internal Revenue Service and the Italian Justice Department. (DX 165, p. 15.) Over 30 percent of the 2000 Series orders reportedly represented "systems to supplement existing [Honeywell] 200 computers or for new customers". (DX 10031, p. 32.)

e. NCR. In the years 1970, 1971 and 1972, NCR's corporate earnings declined precipitously, from a $30 million profit to a net loss of nearly $60 million. (DX 398, p. 1; DX 341, p. 1; DX 354, p. 1.) According to its management, these earnings declines were due to several factors:

(i) 1970: "1970 earnings were severely affected by the slowdown in the U.S. economy . . . retraining expenses and an unusually large $11 million write-off of inventories for LIFO valuation". (DX 373, p. 3.)

(ii) 1971: "A 16-week strike by the United Auto Workers union which idled 8,500 production and maintenance employees at the Dayton factory . . . . Year-end write-offs totalling $17 million after tax for (a) parts inventories for certain older products . . . and (b) heavy costs relating to the re-engineering" of a computer system. (DX 341, p. 2; DX 373, pp. 3, 4.)

(iii) 1972: "The heavy year-end charges [$70 million] were due primarily to NCR's transition from mechanical products to new electronic products. They included provisions for restating the value of parts inventories used in the manufacture and servicing of older mechanical products; for the costs of realigning manufacturing facilities to meet the production requirements of new types of products; for improving the performance of certain existing products; and for the writeoff of previously deferred marketing costs." (DX 354, p. 2.)

In 1973, NCR reversed its poor earnings record: its corporate revenues increased by 17%, from about $1.5 billion to $1.8 billion; its earnings rose from a loss of nearly $60 million to profits of about $72 million, the highest profits in the company's history. (DX 339, pp. B, 1.) And by that year, NCR had all but completed its transition from mechanical to electronic products and its computer business "moved into the black". (Id., p. 2.)

During the early 1970s, two significant developments affected NCR's data processing business. First, in May 1972, William S. Anderson became NCR's President and in July 1973 NCR's

Chief Executive Officer. (DX 354, p. 1; DX 339, p. B.) Anderson had formerly headed NCR Japan. (Id.) When he assumed control, Anderson recognized that NCR was "in trouble". He stated that his first task was to "arrest the steep operating profit slide which began in 1970" and "to move the company successfully through the transition from mechanical to electronic products". (DX 3354, p. 3.) In the first two years of his tenure, Mr. Anderson directed extensive reorganizations of NCR's manufacturing, research, development, marketing and administrative operations. He also made a number of management changes and reduced the size of NCR's work force. (DX 354, pp. B, 2-3; DX 339, pp. 2, 4, 5-6.)

Second, during these years NCR made no major "systems" announcements of the type undertaken by IBM, Burroughs, DEC, Honeywell and others. NCR had been late in announcing its third generation family, the Century Series, and did not begin shipments until 1968. (See pp. 660-68 above; DX 340-A, p. B.) In 1970 and 1971, NCR did not try to replace that line, but instead, announced two new additions, the Models 50 and 300. (Hangen, Tr. 6327-29; DX 398, pp. 5, 13; DX 341, p. 17.) The company also expanded its network of data services. (DX 398, p. 4.)*

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* From a nucleus of three domestic data centers in 1960, by 1970 NCR had established a worldwide network of 80 such facilities. During the early 1970s, these centers steadily increased their volume of data processing applications. (DX 398, p. 4.) The data centers performed a "variety of types of work", including merchandising, inventory control, banking and payroll applications. (Oelman, Tr. 6163.)

The other new computer products NCR announced at the outset of the seventies were industry-oriented terminal subsystems and their associated on-line control software.

In 1970, the company introduced the NCR 280 Retail System, another example of an "intelligent" terminal system, similar in concept to Burroughs' "TC" equipment. (Oelman, Tr. 6141; see pp. 651-52 above.) Oelman testified that an "intelligent" terminal has the capability of performing standalone processing, while a "dumb" or "interactive" terminal can only function in conjunction with a computer that provides processing capability. (Tr. 6182-83.) The NCR 280, as announced, included input/output equipment (even electronic "wand[s]"), data storage equipment and communications equipment, together with the necessary software to permit the subsystem to operate as part of larger NCR computer systems. (DX 398, p. 3; DX 375, p. 3; DX 409, pp. 1, 4, 5; DX 425A, p. 2.) By 1971, the 280 System was highly successful. (DX 341, p. 3.)

In 1971, NCR introduced its 270 Financial System, a series of teller-terminal subsystems that could be linked directly "on-line" to NCR central processing units. The 270 was, according to NCR's management, the most advanced system developed for the handling of customer transactions in savings institutions and commercial banks. (DX 341, p. 3.)

Also in 1971, NCR announced the 399 Series, which was said to combine "the advantages of a general-purpose, operator-oriented accounting machine with the speed and computational abilities of a computer". (DX 341, p. 3.) Also in 1972, NCR introduced an enhanced version of the 270 financial terminal subsystem, the 275, which was a free-standing financial terminal for commercial banks. The subsystem could be used either as an independent unit or as part of a single computer system in the event the using bank moved to an on-line configuration of its computer system. (DX 354, p. 7.)

NCR's growing experience and capability in the on-line approach to data processing, involving remote storage, processing, communications and supporting control programs was the kind of capability that later turned out to be highly relevant to the development of distributed processing systems. Moreover, terminal subsystems were one of the most rapidly growing products in the data processing industry in the 1970s. NCR's management observed in 1973: "Just as the computer provided the most dramatic advances in information processing during the 1960s, so the data terminal is emerging as the key development of the 1970s." (DX 354, p. 7.)

f. <u>Sperry Rand.</u> In November 1970, Univac announced a new large-scale general purpose processor, the 1110, with "advanced proven software", "for today's full range of applications, whether local or remote, batch, time-sharing or real-time, business or scientific". (DX 8060, p. 1; see Cary, Tr. 101618-21; DX 14410.) This system built on the success of the company's 1108. (See pp. 477-81 above.) However, Sperry apparently perceived itself as trailing behind IBM in processor design. In a 1971 memorandum, Dr. J. P. Eckert, one of the pioneers in computing, wrote to McDonald of Sperry Rand:

> "The engineering problem that Univac faces is that every program to build a large computer and much else, has been a sort of 'crash' program. In the case of the 1110 and 1195, the crash has not been due to any lack of time or facilities or manpower, but just due to awful planning and poor technical foresight. The 1195 is now being planned as a 'cache memory' machine which, except for some interesting and valuable improvements in the cache design and an adaptation of the cache design to Univac 1100 series and 490 series techniques, is simply following <u>IBM's lead almost exactly</u>. Now what doesn't make sense is this. IBM gave out at talks, and in papers, sufficient information to enable us to go the cache memory route if we liked in 1968. The plans for the 1110 were not very advanced at that time. In addition to the information in IBM's own publications, Dr. Spandorfer and I attended meetings at which Gibson of IBM explained the cache memory and we of course, relayed this additional information to Univac. No serious work however, apparently took place on a cache memory until about six months ago. In other words, we knew about the cache memory three years ago but only looked into the matter seriously, six months ago. Now on the 1195 we find ourself not only copying IBM but we have wasted two and a half years of lead time in the copying we are doing." (DX 9, p. 1, emphasis in the original.)

In 1971, IBM employees and the trade press reported that Sperry had taken several actions to reduce the prices of its current Univac 9200 and 9300 computer systems, including new long-term leases at discounted rates (April), and packaged configurations (August and October). (DX 14225; DX 14226; DX 14227; DX 14283; DX 14382.)

In November 1971, Univac introduced the 9700 computer in its 9000 line. (DX 3285, p. 3.) Also in November 1971, Sperry and RCA reached an agreement in principle for Sperry to acquire RCA's computer business. (PX 406, p. 1; see generally, pp. 613-14 above.) The agreement, which was finalized in December 1971, called for an initial payment by Sperry of $70 million, and a future percentage of revenue payments that would total up to $60 million. (PX 406, p. 1; Conrad, Tr. 14130.) According to Sperry's management the acquisition of the RCA business enhanced Univac's competitive position in the computer industry. (PX 406, p. 2.) RCA then had more than 1,000 computer installations and in excess of 500 customers (PX 406, p. 2.) J. Paul Lyet, Sperry's Chairman, and Robert E. McDonald, President, reported to the stockholders that in calendar year 1972 Univac had shipped "more than $130 million in new equipment . . . to these users [RCA customers]. . . . We are continuing to build 'bridges' between the RCA systems and Sperry Univac's line". (DX 63, p. 1.)

As noted above (pp. 616), as of December 1974, the RCA equipment had yielded to Sperry a "revenue stream (sales, rentals and maintenance) for 3 years of approximately $370 million" and Sperry believed that "[t]hese benefits will certainly not end at this point". (DX 68, p. 12.) In May 1975, approximately 76% of the RCA equipment acquired by Sperry Rand was still on rent. (McDonald, Tr. 4045-46.)

In 1973, Sperry Rand made another important acquisition: Information Storage Systems (ISS).

In 1973, ISS was a major manufacturer of computer disk subsystems. (See p. 329 above.) Its acquisition provided Univac with significant in-house peripheral capability. At the time of the acquisition, ISS was also a major supplier of IBM plug-compatible disk products to such firms as Telex, Itel and Storage Technology Corporation. (McDonald, Tr. 4056-64; DX 86A, p. 2. (Appraisal section).) As part of Univac, ISS continued to supply plug-compatible replacements for IBM disk products and also became the developer and manufacturer of disk subsystems for use in Univac systems. (McDonald, Tr. 4061-62.) Univac's appraisal of the proposed acquisition emphasized the fact that in terms of disk storage capability, without ISS Univac was "lag[ging] behind industry leader [IBM] by two years". (DX 86A, p. 1 Appraisal Section.) That appraisal also forecast an

> "additional profit of $50 million resulting from the sale of additional computer systems resulting from the competitive advantage the [ISS] advanced products give us over our present capabilities and methods. While this is subject to judgment factors, there is no doubt the more timely availability of competitive products will enhance the marketability of entire computer systems as well as the disc subsystems themselves." (DX 86A, p. 1.)

62. IBM plug-compatible peripheral equipment manufacturers The firms which had been manufacturing plug-compatible memory and peripheral equipment for IBM System/360 computer systems were compelled to respond to IBM's introduction of System/370 in 1970 and 1971, particularly in those areas where each of the PCM's had been marketing products.

In these years, a number of manufacturers first began to offer IBM plug-compatible equipment, including CDC, with its expanded peripherals business, Univac, through its acquisition of ISS (see p. 826 above) and Storage Technology, a new company, and semiconductor firms who were being attracted to the computer industry, like National Semiconductor and Intel. (See pp. 1200-08 below.) And at the same time other existing manufacturers of IBM plug-compatible peripheral and memory equipment also attempted to match IBM's System/370 product and pricing actions.

a. Telex. Telex was one of IBM's earliest "plug-compatible" peripheral equipment competitors (see pp. 763-65 above) and reacted quickly to IBM's 360 and 370 announcements in 1970-71.

Tape Subsystems. One day after IBM announced its 3420 tape subsystem in November 1970, Telex told its salesmen that it would have comparable products ready for delivery "very shortly after IBM deliveries". (DX 1780, emphasis in original; see JX 38, p. 981.) In December 1970, Telex formally announced its 6420/6803 tape subsystem, a plug-compatible version of the IBM 3420/3803. (DX 4242, p. 8; DX 1699; DX 1746; DX 4756B, pp. 126, 128.) Telex had also hired Howard Gruver away from IBM. Gruver had been IBM's Product Engineer with responsibility for development of the new 3803 tape drive control unit, announced with the 3420 in November. (DX 1699; DX 5155, Gruver, pp. 44-45, see also pp. 197, 206-07.)*

Telex began deliveries of the 6420/6803 subsystem in November 1971, and in 1972 reported that it was one of Telex's "most successful product introductions". (PX 5602, pp. 8-9.) Shipments of the 6420/6803 subsystem through 1972 exceeded Telex's announcement forecast: over 2,000 6420 tape drives were shipped by December 1972, as compared to the 1,575 that had been forecast in November 1970; nearly 700 6803 controllers were shipped by December 1972, as compared to the 520 originally forecast. (DX 4240, p. 1.)

Telex also responded to IBM's Fixed Term Plan announcement of May 1971

> "by announcing additional downward adjustments in its own lease rates, effective July 1, 1971. The new Telex rate reductions are incorporated in formulas which relate to length of lease term and other variables. In general, however, they preserve historical rental differentials between Telex units and comparable IBM units." (DX 4242, p. 6.)

<u>Disk Subsystems.</u> In 1969, Telex began marketing IBM plug-compatible 2314-type disk subsystems manufactured by ISS. (James, Tr. 35092-94; DX 4250, p. 4.) In the fall of 1970, following IBM's

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* As early as April 1970, at a "Business Planning Staff Meeting", top Telex management decided that the company would "[i]dentify and recruit from IBM a product engineer with tape controller experience and 'Aspen' capability." (DX 1676.)

When Telex salesmen were told they would "very shortly" have a 3420-type product, the "tangible evidence" was said to be Howard Gruver. (DX 1780.)

3330/3830 disk announcement in June, Telex began to recruit an in-house 3330 development team (DX 4192) and in December, Telex hired John K. Clemens, IBM's Merlin program manager, who was then involved with IBM's "Iceberg", double capacity 3330 development program. (Ashbridge, Tr. 34983-85; DX 1926, p. 23; DX 3260A; PX 4539.) Telex also hired or recruited several other IBM engineers for its disk development program.* (DX 4739: Wilmer, Tr. (Telex) 4266, 4292-93; DX 4742, Kevill, pp. 71, 74, 88; DX 9009: Ahearn, Tr. (Telex) 5326-28; DX 4738: Wade, Tr. (Telex) 4340, 4348-54.)

While that recruiting activity was under way, Telex also tried to negotiate an OEM agreement with ISS to obtain 3330-type IBM compatible products; that effort was unsuccessful. (James, Tr. 35092-97.) Telex then turned to CDC, with which it reached agreement in early 1971 to obtain 3330-type disk drives to be marketed by Telex with Telex's own 3830-type controllers. (James, Tr. 35097-98; DX 1925; DX 4242, p. 6.) However, as late as February 1972, approximately six months after IBM had begun shipments of its 3330/3830 subsystem, CDC's disk drive development failures made it apparent to Telex that the project was unlikely to succeed. (See DX 4181; DX 2373-A.) During this same time, Telex was still encountering difficulties in producing the control unit for the CDC drives

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* In June 1972, Telex's discussions about recruiting for disk expertise indicated Telex would continue the practice of hiring IBM employees to get IBM talent "in order to stay current". (DX 1737; DX 4286.) They were not after "skill per se, but information". (DX 1895, p. 3.)

(DX 1532) and terminated its in-house program, after learning it could purchase the controllers more cheaply than it could manufacture them itself. (DX 1720; DX 4107, Williamson, pp. 269-70; DX 4742, Kevill, pp. 290-95, 319-21.) Key Telex employees, including Clemens, left the company because of the failure of the in-house controller efforts. (DX 1758; DX 4742, Kevill, pp. 313, 317, 448-50.) Telex ultimately acquired 3330-type products from ISS (Navas, Tr. 40243; PX 4354, p. 57; PX 5602, p. 8) but was able to ship less than 200 units by the end of 1972. (DX 4240, p. 2.)

Telex's Difficulties. From its fiscal year ending March 31, 1969 to the year ending March 31, 1970, Telex had reported dramatic rises in revenue (+68%), in net income before taxes (+288%) and in net income after taxes (+285%). Beginning in fiscal year 1971, however, that picture changed significantly. In fiscal year 1971, Telex's reported net income before taxes decreased by 6% and net income after taxes increased by only 5%. And, in fiscal year 1972, Telex's reported revenues were down 10 percent and net earnings before taxes and net earnings after taxes were down 59% and 57%, respectively. Finally, in fiscal year 1973, reported revenues had dropped to $68.1 million and Telex reported a loss of $13.3 million. (DX 4250, p. 2; DX 4242, p. 4; PX 5602, p. 16; PX 5603, p. 2.)

Several factors contributed to this business reversal.*

First, in May-August 1971, Telex had a production line strike. (Ashbridge, Tr. 34993-94.) The strike "created serious problems" for Telex's field service personnel affecting field service costs and morale, and customer satisfaction. Worker dissatisfaction prior to the strike, and the recruiting after the strike contributed to Telex's quality control problems. (DX 1748A.)

Second, in 1970-1973, Telex had manufacturing and performance problems with its older 5420 tape systems, a PCM version of IBM's 2420, as well as with the company's newer 6420. (DX 1884; DX 1736; DX 1949; DX 1948.) By mid-1972, Telex field executives viewed the entire 6420 program as "a major disaster", and considered the quality of parts, etc., to be "pitiful". (DX 1765.) During these same years, Telex's manufacturing operations were in serious difficulty. (See DX 4742, Kevill, p. 115; see also DX 4106, Ice, p. 706; DX 5155, Gruver, pp. 127-128, 133, 144-51, 155, 344-49; DX 4733, Justice, pp. 157-59; DX 4735,

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* The financial data from 1970 and 1971 included "front-loading" of income that accounting experts then found improper under generall accepted accounting principles. (See Briloff, Tr. 80723-24, 80992-95, 80998-99; Davidson, Tr. 98713-29; DX 1612; DX 3786: Briloff, Tr. (Memorex) 14-17, 20-26.) In 1971 and 1972, Telex began to change its accounting methods; had Telex used appropriate accounting methods to begin with, its reversals beginning in 1971 would not have appeared so precipitous. (Briloff, Tr. 81197-202; Davidson, Tr. 98719-20, 98726-29; DX 4242, p. 17; PX 5602, pp. 21-22.)

Jones, pp. 159-60; DX 4168.)

In the spring of 1972, when James became President of Telex Computer Products, he was immediately given responsibility to "correctthe [sic] failure of our manufacturing department to produce quantity and quality of tape drives comparable to our competitors". (DX 1878; DX 1878A.) By then, Telex's manufacturing operations were "in a state of near disaster and on the verge of total collapse". (DX 4279; see DX 4107, Williamson, pp. 694-97; DX 1855.) In May 1972, Wheeler, Telex's Chairman of the Board, informed the Telex Board that Telex had "fall[en] into a period of little shipments because of lack of new product. . . . In the past we see a steady buildup through 1970 to mid-1971 of product being shipped . . . and then through the balance of 1971 and into early 1972 we do not have product to ship." (DX 1742.) Wheeler indicated that during this "product valley", Telex's quarterly sales value of computer peripheral equipment had fallen from about $25 million in the first quarter of 1971 to an estimated $9.8 million in the first quarter of 1972. (DX 1742; see also DX 4278, p. 3; DX 5155, Gruver, pp. 357-65.)

While Telex was experiencing these manufacturing and reliability problems, other plug-compatible competitors were announcing and delivering newer products and offering new terms and conditions, particularly a new company, Storage Technology Corporation (see pp. 1011-15 below):

(i) In the weeks prior to April 1972, STC displaced more than a hundred Telex tape drives primarily because of Telex's inability to deliver its 6420/6803's. Wheeler termed Telex's low productivity a "debacle". (DX 1533; see Ashbridge, Tr. 34997-99; PX 3981: Ashbridge, Tr. (Telex) 610; DX 1946; DX 1731.)

(ii) By April 1972, Telex salesmen had been told to decline any orders for delivery of the 6420s until September 1972; Telex management realized that this was "an inexcusable tragedy that would result in further losses to STC and was "a direct reflection upon the management competence of Telex". (DX 4164.

(iii) Later in 1972, STC bid against Telex and won on a five-year lease of 218 tape drives and 24 controllers to the Ford Motor Company, at prices 10 to 12 percent below Telex's prices. (See DX 1732.)

(iv) It was not until December 1972 that Telex was able to equal STC's production of tape units. (See DX 4279.)

During the early 1970s, Telex's disk subsystem difficulties--already mentioned--were also particularly significant, since the "financial success" of Telex's fiscal year 1973 business plan depended "to a large extent" on its expected disk shipments. (DX 1683.) And in this area, as in tape systems, Telex found it difficul to match the price reductions of its competitors. (See DX 4123; DX 1749; DX 1768.)

<u>Telex's turnaround.</u> During Telex's fiscal year 1974, the company increased its revenues to above its 1971 levels but still

reported a loss. (PX 5604, p. 2.) The next year, however, the company returned to a profitable position, with revenues of $106.1 million. (PX 5605, p. 2.) In 1977, Telex reported revenues of about $120 million (PX 5607, p. 2) and by 1979, revenues were $148.2 million. (DX 13690, p. 18.)

As of 1975, Telex was marketing:

> "tape drives, disk drives, printers, memories and communications controllers all of which . . . are intended to be and are directly plug-to-plug compatible with the central processing units . . . manufactured by . . . (IBM). The above equipment is either designed and manufactured by [Telex] or it is purchased from other suppliers and marketed by [Telex] to the computer end-user. [Telex] also engages in the business of supplying tape drives and tape and printer controllers to other peripherals companies under what are known as OEM . . . contracts." (PX 5605, p. 4.)

During the remainder of the decade, Telex further expanded its product line. Much of that expansion resulted from a series of acquisitions:

(i) In December 1976, Telex acquired the terminal product division of United Technologies Corporation. Telex reported in 1979 that its Terminal Communications Division had used "the latest advances in microprocessors and integrated circuit technology" to develop "new terminals with capabilities not thought possible a decade ago." (DX 13690, p. 5.) Among the division's products was REACT (Remote Access Communications Terminals), "a programmable terminal which dramatically enhances the communication network and thus reduces total operating costs of users with their own message switching networks."

(Id., p. 6.)

(ii) In January 1977, Telex acquired Gulliver Technology. "[T]he combined engineering efforts" of the two companies resulted, in 1978, in the introduction of a 6,250 bit per inch tape drive "for use by minicomputer manufacturers for their tape drive needs." (DX 13689, p. 3; DX 13690, p. 4.) The following year, Telex introduced an "end-user version" of this same tape drive (DX 13690, p. 4), which, like its OEM counterpart, featured data storage density for "minicomputers" equivalent to the top of IBM's tape drive line, the 3420-4, 6, 8 or "Birch". (See pp. 1054-55 below.)

(iii) In 1978, Telex acquired General Computer Systems (GCS). (DX 13689, p. 4.) GCS' major product was the 2100, which

> "utilizes terminals employing keyboards and video display tubes linked to a central processing unit which also supports magnetic disk drives or tape drives, card readers, communications lines, line printers and other devices. . . . The system enables operators to detect and correct errors, do mathematical computations, and format processed data at the time it is entered." (DX 13689, p. 5.)

b. Storage Technology. Storage Technology Corporation was founded in August 1969 by Jesse Aweida and three other men who left IBM's tape subsystem development program in Boulder, Colorado, to set up the new company.* (Aweida, Tr. 49099-49101; DX 2151; PX 4702, p. 4; PX 4708-A, pp. 15-18.)

The start-up investment for STC was about a quarter of a million dollars, supplied by the founders and J. H. Whitney and Company, a venture capital concern. (Aweida, Tr. 49099-100; PX 4705; PX 4708A, pp. 8, 15-18.) Between January 1970 and January 1971, private placements of STC stock raised an additional $6.2 million. (PX 4702, p. 4; PX 4705.) In June 1971, the company's first public stock offering raised another $3.75 million. (PX 4702, p. 4.) Another public offering in 1972 brought in $8.2 million and in that same year, STC secured a $20 million credit line from a group of banks, including Citibank in New York. (PX 4702, p. 5; PX 4699, p. 5.) In October 1973, the credit line was increased to $40 million. (PX 4701, p. 5.)

The company's first product was a line of IBM 24XX plug-compatible tape drives, announced and exhibited in May 1970, nine

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* Prior to leaving IBM, Aweida had been the program manager of IBM's 2420 Model 7 tape drive. (Aweida, Tr. 49080-81.) Aweida testified why he left IBM to form STC:

> "I felt there was a market opportunity for me to establish a new business, run my own company, and make a lot of money.
>
> ". . . .
>
> "At the time it looked like the high performance tape drive market was expanding, and there was a lot of demand for a good product in that area." (Aweida, Tr. 49099.)

Also, many of STC's key engineering personnel were former IBM employees. (PX 4708A, p. 2.)

months after the company was formed. (See PX 4702, p. 4; PX 4708A, p. 2; see also Aweida, Tr. 49112; PX 4699, p. 6.) The first deliveries of those products were made just four months later, in September 1970. (Aweida, Tr. 49112; see PX 4708A, p. 2; PX 4702, p. 4.)

Later that same year--within one month of IBM's 3420 tape subsystem announcement--STC announced an IBM 3420 "equivalent" system. (PX 4708A, p. 7; see PX 4699, p. 6.) According to STC, "the IBM [3420/ 3803] announcement with its emphasis on advanced features and a total subsystem approach . . . clearly brought STC to the fore as one of the strongest competitors to IBM". (PX 4708A, p. 51.) In the words of STC management at the time:

> "In summary, while the IBM announcement of the 3420/3803 line of tape equipment represents a significant move by IBM, STC management is confident that the net effect on STC is a positive one. It is expected that the market will expand for newer more advanced tape subsystems which STC offers. The increased quantity will result in some increase in financial requirements to finance the leased equipment in 1971 and 1972, but should result in an increased level of growth and profit over the next three to five years." (PX 4708A, p. 53.)

In fact, STC grew phenomenally in the early 1970s and beyond. (see pp. 1121-24 below.) In 1970, STC had no revenues. (PX 4699, pp. 4, 8.) In 1971, STC had revenues of about $3.6 million. (<u>Id.</u>) Then in 1972, STC's revenues jumped to $28 million. (PX 4703, p. 3.) By 1974, revenues had climbed to over $75 million (PX 4702, p. 15)--about three times what was projected by STC's investment bankers in 1969. (DX 2191, p. 17; DX 2183; Aweida, Tr. 49781-83.)

This growth was fueled by an aggressive product and marketing program:

(i) In 1971, STC signed an agreement with Decimus Corporation, a subsidiary of Bank Americorp, for Decimus to purchase up to $21 million worth of STC equipment over three years, leased to end users. (PX 4699, p. 5; Aweida, Tr. 49198.)

(ii) In 1972, STC announced a new IBM-compatible tape drive, the 3480, reportedly featuring greater speed and transfer rate than any of IBM's 3420-series tape products. (PX 4700, p. 8; PX 4701, p. 27.)

(iii) In September 1972, STC branched into disk products and began shipments of 3330-compatible disk subsystems that it acquired from ISS. (See PX 4699, pp. 5-6; PX 4701, pp. 9, 29; PX 4700, p. 9.)

(iv) Still in 1972, STC began to market IBM plug-compatible semiconductor memory, acquired from Intel. STC's first memory products were semiconductor replacements for IBM's core memory on the 370/155 and 165 processors. (PX 4700, p. 10; see also PX 4703, p. 25.)

(v) In January 1973, STC formed a subsidiary, Disk Storage Systems (DSC), to develop and manufacture disk subsystems and in October of that year announced its first disk product developed in-house, the 8000 Series Super Disk.* The

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* The 8000 Series was originally planned for customer shipments in the fall of 1974, but because of development problems, actual shipments were delayed until early 1975. (Aweida, Tr. 49342-44; PX 4701, pp. 5, 29, 31; PX 4702, p. 26.)

8000 Series offered storage capacity of up to 800 million bytes per module--four times that available with IBM's 3330 disk drive, announced in June 1970, and twice that of IBM's 3330-11, announced in July 1973. (DX 1437; PX 4539.) According to STC, in certain configurations the 8000 Series offered savings of as much as 50 percent over IBM's 3330/3830 subsystems of equal storage capacity. (PX 4701, pp. 5, 29, 31; DX 10647; see Aweida, Tr. 49342-45.)

(vi) In March 1973--the same month that IBM announced its 3420-4, 6 and 8 ("Birch") tape drives--STC announced plug-compatible products of equivalent storage density and speeds. (PX 4700, pp. 4, 8; PX 4701, pp. 4-5, 27; JX 38, p. 1104; DX 7358.)

In 1973 and 1974, STC expanded its product line still further by marketing tape drives and controllers for use with computers manufactured by companies other than IBM. In January 1973, STC entered into an OEM agreement with CII, a French computer manufacturer, for STC tape subsystems. (PX 4700, p. 5; PX 4701, p. 27.) In that September, STC introduced 3400 series subsystems for attachment to Univac processors. (PX 4701, pp. 4-5, 27.) And in October 1974, STC signed agreements with DEC, CII and Siemens to supply their requirements for high performance tape subsystems. (PX 4702, p. 5; PX 4703, p. 14.)

c. Memorex. Following IBM's announcement of its 3330/3830 disk subsystem in June 1970, Memorex moved to develop a competitive offering. (Gardner, Tr. 37265-66.) In October 1971, Memorex announced its 3670 disk subsystem, which was a plug-compatible replacement for the 3330/3830. (DX 4756C, p. 150; DX 10370; see also Gardner, Tr. 36923, 37265-66.)

In late 1970 and through the spring of 1971 and beyond, Memorex also announced price reductions first on its 2314 and then on its 3330-type subsystems in response to price reductions by IBM and other disk subsystem suppliers. For example:

(i) Competitive pressure from such companies as Telex, CalComp and Ampex forced Memorex to "cut their rates significantly". (DX 1636 p. 1; see Saalfeld, Tr. 44764-69; PX 4841, pp. 14-16; PX 4472, pp. 12-13; DX 1495.)

(ii) Following IBM's 3330, 2319 and Fixed Term Plan announcements, Memorex reduced prices on its disk products and announced more attractive terms and conditions on its own longer term leases. (Spitters, Tr. 42901-02; PX 3698; PX 4472, pp. 14-16.)

In those years, Memorex experienced a continuing strong demand for its disk products. For example, in its 1971 Annual Report, Memorex reported that its "placements of [3660] disk file equipment", Memorex's plug-compatible 2314 replacement, "were twice those of the next leading independent supplier" (DX 1270, p. 5), and in its 1972 Report, the company noted the "high level of customer demand" for the 3670. (DX 1271, p. 13.) In the years 1973 through

1976, Memorex's 3660 family of disk products was profitable in each year and the 3670 line returned a profit of over $30 million. (DX 1526, pp. 2-4; see JX 59.)

The Memorex company as a whole, however, experienced severe difficulties in the early 1970s. In 1970, Memorex's total corporate revenues were about $79 million with net income of approximately $3.2 million. The majority of these revenues came from computer tape and media sales, not from EDP equipment. (DX 1269, pp. 1, 17.) By the years 1971-1973 Memorex recorded substantial losses. (DX 1270, p. 16; DX 1271, pp. 1-2; DX 1272, pp. 2, 11.) By 1973, Memorex also had senior debt, principally from the Bank of America, totaling more than $180 million (DX 1272, pp. 5-7, 22-26, 36-38; PX 4341, pp. 14-18, 20-21), but had had to shelve at least two proposed equity offerings. (Spitters, Tr. 43095-96, 43106-07.)

Two significant factors contributed to these financial woes:

<u>First</u>, a series of product failures and revenue and profit short-falls:

(i) In 1970-1973, a principal part of Memorex's business, the media business, disk packs, video tapes and computer tapes, suffered from lowered demand, severe price competition and poor management. (See, for example, Saalfeld, Tr. 44754-56; Spitters, Tr. 55129-30; DX 1269, pp. 1, 3, 17; DX 1604A, pp. 3-4.) As a result, Memorex's media revenue for the entire 1970-1975 period fell nearly $450 million short of its projections in 1970. (See Spitters, Tr. 55223-26; DX 2559, pp. 40-41; DX 1273, p. 16; DX 1274, p. 24.) Spitters, Memorex's Chairman at the time, admitted that in the media business, "[t]he results were unsatisfactory". (Tr. 55131-33.)

(ii) In 1970, Memorex began shipping Computer Output Microfilm (COM) equipment, for use in computer systems (DX 1269, p. 2), without a market research study and based solely on Spitters' recommendation. (Spitters, Tr. 54295-300, 54310-11; DX 1280, pp. 4-6.) In 1970, the company set a 1972 sales revenue goal on the order of $250 million, in which its COM projections figured importantly. (Spitters, Tr. 54295-98; 54310-11; DX 1268, p. 5.) Initial demand for the product, however, was weak. (DX 1269, pp. 3, 10.) The results through 1973: a short-fall of nearly $60 million, with the COM business achieving less than 10% of its projections. (See Spitters, Tr. 54316-26; PX 4288, pp. 9, 29; DX 1282, p. 5.)

(iii) Through 1973, Memorex missed its sales volume projections by over $44 million in its new computer terminal business. The program lost money and Spitters advised his successor, Wilson, to cancel the program. (See Spitters, Tr. 55316-20; PX 4288, pp. 9, 29; DX 1282, pp. 5, 10-11.)

(iv) In 1972 and 1973, Memorex encountered manufacturing and quality problems with its new IBM plug-compatible disk products. (See, e.g., DX 1461; DX 1463; DX 1464; DX 1465; DX 1470; DX 1481.) For example, in December 1972 and early 1973, manufacturing was so seriously behind its original commitments for the 3670 that the company's management feared a loss of credibility and of customers; problems persisted until at least November 1973. (DX 1465, p. 3; DX 1461; DX 1470; DX 1481.)

(v) In 1972, Memorex introduced two computer systems, the Memorex Model 40 and 50. (DX 1271, p. 2.) At that time the firm did not have adequate financing and Spitters later admitted that Memorex's financing strategy for systems had been wrong. (Spitters, Tr. 55090-98.) After delivery, the largest single customer for the systems canceled because of the products poor performance. That performance led the customer to conclude simply that the systems did not "perform satisfactorily". (DX 2560; Spitters, Tr. 55181-86, 55328-30, 55421-26; DX 3405; DX 3404.) Memorex's systems program was canceled in July 1973. (Tr. 32498 (Stipulation); DX 1272, p. 20.)

Second, a combination of recognized poor management, management upheavals and adverse publicity over Memorex's accounting practices contributed to Memorex's difficulties during the early 1970s and made acquisition of additional capital difficult for the company.

There had been public "skepticism" expressed about Memorex's accounting practice of deferring expenses for lease acquisitions and for research and development even in the early part of 1970. (See, e.g., DX 1319; DX 3063-A; DX 3013; DX 2493, pp. 5-6; DX 2494, pp. 1-2; Spitters, Tr. 54256-58, 54263-68, 54337-41.) Matters became worse in November 1970, when, following a Wall Street Journal article criticizing Memorex's accounting, the New York Stock Exchange suspended trading in Memorex stock (Spitters, Tr. 54605), an SEC investigation began, and the SEC later sued the company and two of its executives for securities fraud. (DX 1696A.) The government's suit was settled in 1971, but private suits continued (DX 2469; DX 1628; DX 1629; DX 1630; DX 1631A) and more controversies arose over the firm's accounting practices until 1973, when these practices were changed and over $37 million of accumulated expenses were written off against current revenues. (See, e.g., DX 1272; DX 2504A; DX 2513A; DX 1632; DX 1643A; DX 1645A.)

Throughout the 1970-73 period, Memorex was the subject of numerous articles questioning the accuracy and appropriateness of its public financial reports. (See, e.g., Spitters, Tr. 55033-35; DX 1625A; DX 1628; DX 1629; DX 1630; DX 1631A; DX 1644A; DX 2504; DX 2504A; DX 2513A; DX 1643A; DX 1644; DX 1645A.)* These articles damaged the credibility of Memorex and its management in the eyes of the country's financial community. (DX 2518, see

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* Sidney Davidson, Arthur Young Professor of Accounting and former Dean of the Graduate School of Business at the University of Chicago, testified at length about Memorex's accounting practices. Professor Davidson, who served on the Accounting Principles Board ("APB") of the American Institute of Certified Public Accountants from 1965 to 1970 and was, for most of that period, Chairman of the Subcommittee on Accounting for Leases (Davidson, Tr. 98693; DX 9431), concluded that Memorex's accounting practices violated generally accepted accounting principles in at least four areas, which tended to overstate Memorex's earnings "materially" for the years 1966 through 1972. (Davidson, Tr. 98754-61; DX 9435.)

Rice, Tr. 45370-71.)

In these same years, the banking and financial community, including the key officers at the Bank of America, came to regard Memorex's management as quite poor. (See DX 1604A; Saalfeld, Tr. 44816-25; Spitters, Tr. 55118-40; DX 2509; DX 2510.) One Bank of America memorandum said bluntly: "Memorex is as mismanaged at its senior officer level as any company we have ever seen." (DX 1610, p. 1.)

During these on-going controversies and various product program shortfalls and cancellations, Memorex's top management underwent major upheavals. The Chief Executive Officer, Vice-President of Finance, Head of the Equipment Products Group and Head of Research and Development left between early 1971 and early 1974. (Saalfeld, Tr. 44674-76.) By 1974, when a new Chief Executive Officer, Mr. Wilson, came in, many of the company's remaining officers had either left or been demoted. (See Rice, Tr. 45281-86; DX 1272, pp. 42-43; DX 1635, pp. 26, 27, 32.)

d. Advanced Memory Systems (AMS). AMS was incorporated in October 1968 to design, manufacture and market semiconductor memory equipment for computer systems. (DX 1976, p. 2; DX 1964, p. 12; see also Fernbach, Tr. 395-96.)* AMS began operations at a time when memory technology was moving from core to semiconductors. In 1970, AMS management reported to the company's shareholders on the switch to semiconductor technology:

> "Customer acceptance of [AMS' semiconductor product] for main computer memory provides further evidence that the change-over from core memory to semiconductor memory is occurring at a rate more rapid than that forecasted by industry spokesmen as recently as one year ago." (DX 1965, p. 3.)

Andreini of AMS testified that the change from core to semiconductor technology affected "the ability of the core manufacturers"--such as Ampex, Fabri-Tek, Standard Memories, CHCS and Data Recall--"to compete successfully for add-on IBM memory business" and, according to him, those core manufacturers did not produce semiconductor memory for IBM System/370 computers. (Andreini, Tr. 48581, 48584-85.)

In the fall of 1970, AMS announced its Semiconductor Storage Unit (SSU), which was marketed as a "completely compatible" add-on memory product for IBM System/360 and System/370 processors. This product featured 1,024 bit-per-chip Metal Oxide Silicon (MOS)

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* AMS obtained $500,000 in start-up private financing from the Diebold Technology Venture Fund, Inc. and Value Line Development Capital Corporation. (DX 1964, pp. 9-10.)

The management and sales force at AMS included many former IBM employees. (Andreini, Tr. 46894; DX 1964, pp. 5, 10-11.)

technology. (DX 1965, pp. 4, 8; DX 1966, p. 5.)* At that time, IBM offered only older core memory technology for its System/ 360 processors and for the 155 and 165 System/370 processors, announced in June 1970. (See PX 4505.) In 1971, AMS announced the development of a memory chip featuring twice the density of its original MOS product. (DX 1966, p. 13.) This 2048 bit-per-chip design was marketed beginning in mid-1972. (DX 1967, p. 5.)

AMS' IBM plug-compatible semiconductor memory equipment won customer acceptance quickly. By 1971, AMS add-on memories had been installed by a variety of IBM systems users, including such customers as The Mennen Company, Hyster, Beckman Instruments, Hughes Aircraft, Time, Inc., Getty Oil, Stanford Research Institute and American Savings & Loan. (DX 1966, p. 9.) After virtually no revenues in 1969 and 1970, AMS' 1972 reported EDP revenues in the U.S. rose to approximately $16 million. (DX 8224, p. 527.)

In 1973, AMS' OEM business was expanded through an agreement with CDC, which gave CDC non-exclusive, worldwide rights to market AMS' System/370 compatible memory product line. (DX 1967, pp. 3-4; see also Andreini, Tr. 46893, 47142-45, 48049-51; Lacey, Tr. 6743-44; DX 1968, pp. 3, 15.) AMS also entered into marketing arrangements with Itel in 1970 and Memorex in 1974 (Andreini, Tr. 46893-97; DX 1965, p. 4), and during the early 1970s marketed its

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* AMS had announced its first memory product in December 1969. It was a very high speed memory intended for functions such as buffering, main memory, high-speed control and register replacement. (DX 1964, pp. 7-9.)

memory products on an OEM basis to a number of processor and peripheral manufacturers, including CDC, Data General, Univac, Amdahl, Raytheon, STC, Honeywell, Fujitsu, Nixdorf, Siemens, Hitachi and Wang. (DX 1968, p. 6.)

Also in 1973, AMS introduced an MOS main memory system for the IBM 370/145, which the company claimed offered better price/performance than IBM's bipolar semiconductor memory on that machine. (DX 1968, pp. 3, 7.) And in 1973, AMS announced a 4,096-bit MOS device. (Id.) In three years, 1972, 1973 and 1974, AMS ran into operational problems: "insufficient production of chips and devices" to meet growing demand. (Andreini, Tr. 48822-28.) Andreini testified that management deficiencies resulted in AMS "not getting the production of sufficient devices in quantity to meet [AMS'] requirements, or at sufficiently low cost". (Tr. 48832.) AMS' revenues increased to over $30 million in 1973 and 1974; however, losses--of $196,000 and $2.1 million--were reported for those years. The losses included write-offs of what by then was AMS' older 360 memory inventory. (DX 1969, pp. 3, 8.) In 1974 and 1975, AMS eliminated some non-productive and unprofitable operations, tightened financial controls, cut development in non-productive areas, and placed more emphasis on profitability in specific product lines. (Andreini, Tr. 48833-41.)

In 1975, the company returned to a profitable position. (DX 2070; DX 1971A, pp. 2, 7.)

Fiscal year 1976 (ending September 26) was, according to

AMS, "the best year in the history of [the company], with sales and earnings climbing to record levels." (DX 1971A, p. 2.) Revenues were over $40 million and profits were nearly $4 million. (Id.) In November 1976, AMS merged with Intersil, Inc., a manufacturer of integrated circuits and microprocessors. (DX 1971, p. 5; DX 2070, p. 1.) In 1979, Intersil introduced the UMS-3 Universal Memory System, "thereby [becoming] the first add-on memory supplier to offer a complete line of 16K memory products for use on the IBM 370/138, 148, 158, 168 and the 3031, 3032 and 3033 computers. The UMS-3 product line consists of one basic design which only requires the change of a few interface cards from one model to the next." Intersil posted over $140 million in revenues in 1979. (DX 14083, pp. 1, 6.)

63. Leasing Companies. As already described, computer leasing companies emerged as major competitors in the EDP industry in the late 1960s. (See pp. 797-830 above.) Leasing companies had generally concentrated on purchases of IBM System/360 computer equipment which they leased to customers on a variety of terms and conditions, at rates typically lower than those charged by IBM ("monthly availability charges" (MAC)) under its rental plan.

In 1969, IBM estimated that leasing companies had purchased $2.5 billion worth of IBM equipment (PX 4504, p. 7)*--$1.1 billion of System/360 CPUs and memory alone. (DX 9416A, p. 1.)

In response both to IBM's introduction of the System/370 in 1970 and 1971 and to other competitive product and price announcements, leasing companies in the early 1970s took a number of steps to make their System/360 equipment more competitive:

First, leasing companies cut prices and offered more attractive terms and conditions for the System/360 equipment they were marketing. With these lower prices, the price/performance of that equipment made it an attractive alternative to the newer System/370 equipment. (See Jakes, Tr. 50193-96; JX 3, ¶¶ 22-23.) For example:

(i) In discussing competition for the new 370/135, an IBM report noted that "[t]he Model 135 provides better

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* In June 1971, the Computer Lessors Association advertised that "independent lessors have $2,600,000,000 of IBM 360 equipment". (DX 1911; Tr. 46360-61.)

price/performance than any currently announced competitive system. Heavily discounted third-party S/360 Models 50 and 65 are its closest competitors." (PX 2685, pp. 49, 57.)

(ii) The same report stated that "the Model 145 must also compete with heavily discounted, third-party S/360 Models 50 and 65." (Id., p. 60.)

(iii) Leasing companies emphasized that they continued to offer significant savings over IBM, including discounts on longer term leases of central processing units--a type of offering not available from IBM until later in the decade. An advertisement run by the Computer Lessors Association in June 1971 stated:

> "IBM's new fixed term rental plan offers a price cut of 8-16% on certain peripherals.
>
> "Is this enough? We think not.
>
> "Independent lessors offer saving of 15-45% based on term, and this includes S/360 CPUs." (DX 1911, emphasis in original.)

Second, leasing companies also increased the price/performance of their System/360 equipment "by modifications of existing hardware and software". (JX 3, ¶ 22.) For example:

(i) An "Extended Disk Operating System" or "EDOS" was developed by The Computer Company. (Enfield, Tr. 20136-37.) This software operating system was "plug-compatible" with IBM System/360 hardware and was claimed to enhance performance of that hardware, beyond that available under IBM's Disk Operating System, or DOS. (Enfield, Tr. 20153-54, 20169, 20186-87.) EDOS was marketed with System/360 equipment by "ten or eleven" leasing companies, including "DPF, Greyhound, CLC, ITEL and Booth[e]" (Enfield, Tr. 20167-69), against IBM 370 equipment. (See Enfield, Tr. 20830-32, 20148-49.) Enfield agreed that the availability of EDOS caused several users to "migrate backwards" from 370s to 360s. (Tr. 20148-49.)

(ii) Itel offered software that enabled customers with certain 360 equipment to use DOS/VS, which was offered by IBM on certain 370 equipment. (DX 14363; see also Friedman, Tr. 50397.)

Third, leasing companies continued to market plug-compatible equipment with their IBM-manufactured processors--again as a means of enhancing the price/performance of their 360 systems. (JX 3, ¶ 14; Navas, Tr. 41274-75; Enfield, Tr. 20827-29; Friedman, Tr. 50397; Withington, Tr. 57002-03; PX 2627, p. 21; PX 2679, p. 31.) For example, leasing companies offered modified 3330-type disk subsystems, with somewhat reduced data rates, for use with their larger System/360 processors. (Friedman, Tr. 50434-36; Enfield, Tr. 20800-08, 21032; DX 4407; DX 1674; DX 2673; DX 2646A; DX 14048.) The 3330 itself was not offered generally by IBM for attachment to

360 processors below the Model 85. (JX 38, pp. 971-74; see also Case, Tr. 72770-72, 78398-99.)*

These actions by leasing companies made their 360 equipment competitive with IBM's 370 equipment well into the 1970s. For example, IBM's "Significant Wins and Losses Reports"** during the years since 1974 show numerous cases of:

(i) IBM's 370 equipment being replaced by leasing company 360s (for example: August 1974 Report, PX 6467, Vol. 1, p. 5; December 1974 Report, PX 6467, Vol. 1, p. 6; June 1974 Report, PX 6467, Vol. 1, p. 9; October 1975 Report, PX 6467, Vol. 2, p. 6);

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* In addition, a number of leasing companies offered "packaged" systems. (Rooney, Tr. 12032-33; Andreini, Tr. 47102; Friedman, Tr. 50395-97, 50467-69, 50529-30; DX 2241.) Itel, for example, offered 360/50s which they claimed performed "better than IBM's 370/135[,][f]or $50,000 a year less". (DX 14048) This system included add-on "monolithic memory, 3330 compatible disks, 3420 compatible tapes and a fast 3215 console". Itel also offered a "DAP Box" which was a combination of plug-compatible memory, tapes and disk and software which it claimed could make a 360/40 as powerful as a 370/125, a 360/50 more powerful than a 370/135 and a 360/65 more powerful than a 370/145. (DX 2646A; see also Withington, Tr. 57038-39.)

** As Akers testified, the Significant Wins and Losses Report is prepared monthly from material generated by the branch offices reporting on competitive situations. Only situations involving more than 20,000 points (monthly rental dollars) are reported; for this reason and because "the number of situations is very low that are reported", the Reports contain "substantially less than five percent of the situations that occur in a given month". (Akers, Tr. 96581-84.)

(ii) Leasing company 360s causing users to cancel orders for IBM's 370 equipment (for example: August 1974 Report, PX 6467, Vol. 1, p. 5; December 1974 Report, PX 6467, Vol. 1. p. 6; September 1974 Report, PX 6467, Vol. 1, p. 7; October 1975 Report, PX 6467, Vol. 2, p. 6); and

(iii) Leasing company 360s being chosen over IBM proposals of 370 equipment (for example: August 1974 Report, PX 6467, Vol. 1, p. 5; June 1974 Report, PX 6467, Vol. 1, p. 9; March 1974 Report, PX 6467, Vol. 1, p. 11; February 1975 Report, PX 6467, Vol. 2, p. 10; March 1975 Report, PX 6467, Vol. 2, p. 10; May 1976 Report, PX 6467, Vol. 3, p. 15).

Despite these competitive successes with their 360 equipment, however, the basis on which many of these leasing companies carried on their 360 business in the late 1960s and the early 1970s was unrealistic.

First, as described earlier (pp. 803-05, 812), during the 1960s many leasing companies used accounting policies--believed by the Morgan Guaranty Trust Company to be among "the most liberal . . . allowed by the accounting profession" (PX 2181A, p. R-1; see also Davidson, Tr. 98765)--which let them report unrealistic profits. (Davidson, Tr. 98763-67.) Specifically, depreciation policies were at the core of the problem: for financial reporting purposes, leasing companies used depreciation methods and lives that were substantially more extended than those used by IBM and other manufacturers for their own equipment. (See pp. 803-05 above; Davidson, Tr. 98762-65.)

The leasing company straight-line depreciation policies, according to the testimony of accounting experts, also led to "the mismatching of pluses and minuses" (Briloff, Tr. 80724; Davidson, Tr. 98766-67), because these policies did not reflect financial reality. The revenues derived from leasing EDP equipment would naturally be highest when the equipment was newest, and lower as the equipment became older. Nonetheless, leasing companies depreciated their equipment in equal amounts each year throughout their lengthy depreciation periods, and in effect assumed their revenue stream would be constant, despite the obvious fact that the computer industry is "subject to rapid technological change". (JX 3, ¶ 9; see also Briloff, Tr. 80724-25, 81057-60; Spain, Tr. 88732-34; Buffett, Tr. 100377-81; Davidson, Tr. 98766-67; DX 3906, Walker, pp. 7-11; PX 4834, p. 43.)

In fact, the price structures of the leasing companies were overtaken by events: their estimates of the period before obsolescence, used as a foundation for their lease rentals, proved too optimistic. When IBM brought out the first models of its System/370 in the early '70s, and other manufacturers did likewise, System/360 became something less than a state-of-the-art system. System/360 could not match the improved price/performance of System/370 without substantial price reductions-which leasing companies' depreciation rates did not take into account. (See pp. 808, 817.)

For most leasing companies, problems were exacerbated by the fact that they had bought their System/360 equipment relatively late in the product life of that system. According to Spain of IBM, as of the time of IBM's initial 370 announcement, "the average age of the System 360 inventory held by leasing companies was in the 2-1/2 to 3-year range, with 7 to 7-1/2 years remaining on the book value life these companies were using for depreciation purposes". (Spain, Tr. 88767-68; see also PX 3485, p. 16.) IBM's internal estimates indicate that over 85 percent of leasing company purchases of 360 CPUs and memory were made after January 1968. (DX 9416A, pp. 1, 3.)

Leasing company managements could have foreseen the rapidly approaching end of System/360's life cycle:

(i) IBM management repeatedly told its shareholders in the later 1960s that it expected leasing company purchases of 360 equipment to diminish, "because of the fact that many of our System/360 products have been on the market for over four years". (See, e.g., DX 13680, pp. 5-6; DX 13387, p. 2.)

(ii) In 1969, a report by Withington stated that, "[t]here is no question that the original 360 models (announced five years ago) will be in one way or another replaced by new models in IBM's line within a few years.

When this happens the value of the original models will presumably drop, and the leasing companies have come to fear that the drop in value will be greater than can be tolerated with a ten-year depreciation schedule starting in 1969". (PX 4834, p. 43.)

In the 1971-1973 period, leasing companies acknowledged "that they had underdepreciated in the earlier years, recognizing the fact that they had overly reported income in these intervening years" and had "to 'bite the bullet' and take the big bath in accounting and take the big write-off to bring the carrying value down to a more appropriate level". (Briloff, Tr. 81068; Davidson, Tr. 98768.) Thus:

(i) Between 1971 and 1973 Boothe Computer Corporation wrote off more than $50 million. (DX 9436; see Davidson, Tr. 98768.)

(ii) Between 1972 and 1974 Diebold Computer Leasing, Inc., wrote off more than $46 million. (DX 9436.)

(iii) Between 1970 and 1974 DPF, Inc., wrote off more than $53 million. (Id.)

(iv) In 1973 Rockwood Computer Corp. wrote off more than $41 million. (Id.)

(v) In 1974 Leasco wrote off $12 million. (See Briloff, Tr. 81068.)

Second, in these years leasing companies, for the first time, were in the position of having to remarket large volumes of equipment coming off longer term leases. Numerous companies were unprepared for this task.

For the most part in the 1960s, leasing companies got a free ride in their computer marketing. "In most cases . . . the sales force of IBM . . . had configured a particular equipment solution. . . . [T]he leasing companies stepped in, relied on the prior work of an IBM salesman and supplanted that sale by offering lower prices." (Spain, Tr. 88752.) Hence, before 1970, leasing companies operated with small marketing forces (Friedman, Tr. 50382)*, and "made little or no preparation for the future need to remarket this equipment". (Spain, Tr. 88752.) When the initial leases expired, leasing companies were faced with remarketing the equipment in direct competition with IBM, one another and other system suppliers. Remarketing meant:

(i) As the Morgan Guaranty Trust Company observed, leasing companies had to increase the size of their marketing staffs at a time when the management depth of many of them was questionable. (PX 3105, p. 8; PX 2181A, p. R-14.)

(ii) They had to match the features in their off-lease inventory with those desired by new customers. (PX

* Itel marketed approximately $130 million worth of System/360 in 1968 (DX 2223, pp. 3, 16), with a marketing staff which began the year at one and increased to "between five and eight" by year end. (Friedman, Tr. 50382.)

2414, p. 16.)

(iii) They had to bear the additional cost of removal and reinstallation. (See id.)

(iv) With much of the inventories coming up at about the same time, they had to face fierce competition among themselves. (Spain, Tr. 88754; see also PX 2181A, p. R-14 and PX 3105, pp. 5-6 for the Morgan Guaranty Trust Company's observation on this point.) As Ryall Poppa in 1971, indicated to the DPF Board of Directors, "[u]n-fortunately, some of our competitors . . . are breaking the rates for relatively short terms". (DX 5634, p. 1.)

(v) Leasing companies, like IBM, faced increased competition from plug-compatible peripheral manufacturers "such as Telex, Memorex, Mohawk, CalComp and Potter, who we offering peripheral devices at prices substantially below those of IBM". (Spain, Tr. 88754.)

A number of leasing companies, such as Boothe, Greyhound and DPF, chose not to invest early in System/370 equipment. In part, they regarded that equipment as merely an enhancement of 360 and not a new generation. (DX 10495, p. 3.) For example, Boothe's President, Williams, is reported to have said that "[t]he equipment is an extension of the 360 line and thus indicates that IBM's true 'fourth generation' equipment is as far away as we had anticipated". (DX 13919.) Similarly, Greyhound initially adopted a "skip 370" marketing program. Other companies adopted a "wait and see" attitude and continued to market their 360s in the interim. (DX 10495, p. 3.)

Still, a number of older 360 leasing companies, such as Itel, Leasco and Randolph Computer Corp., began to lease 370 equipment soon after it was first delivered. (DX 14362; DX 14375; DX 14448; DX 10208, p. 190.) Itel, as an example, acquired and leased or arranged for others to acquire and lease nearly $1 billion worth of System/370 equipment. (Friedman, Tr. 50773-75.)

As the 1970s progressed, leasing companies as a group--old and new--acquired IBM 370 equipment for leasing in unprecedented volumes. Leasing company purchase of 370 CPUs, as well as total purchase of 370 CPUs, were significantly greater than leasing company and total purchase of 360 CPUs at comparable points in time. (DX 9416A; JX 4, ¶ 38.) According to IBM's estimates, leasing company purchases of 370 processors and memory were more than double their purchases of 360 processors and memory: in the period 1966 through 1978, leasing companies acquired $612.3 million worth of 360 processors and memory "directly" from IBM and an additional $676 million "indirectly"; in the period 1971 through 1978, leasing companies acquired $2.1 billion worth of 370 processors/memory "directly" from IBM and another $905.1 million "indirectly". (DX 9416A, pp. 3, 5.)

In addition to their System/370 marketing activities, leasing companies also launched programs to purchase and lease IBM

303X computers, announced in 1977.* For example, Welch testified that Chemical Bank received 12 proposals from leasing companies for a single 3032 acquisition. The suppliers offered proposals for three, four and seven years. (Tr. 75270-73.)**

Much of the leasing company activity in System/370 and 303X products came from new companies which had not engaged in leasing 360 equipment, or which had only begun to do so when IBM announced System/370. Among the newer leasing companies are these:

Alanthus

In May 1971, Alanthus began writing leases on System/370 equipment. By the end of the year, it had written leases on

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* Leasing companies have also shown interest in IBM's newest processors, the 43XX series and are offering them for lease: for example, CMI Corp. (DX 13923); Dearborn Computer Company (DX 14351); General Electric Credit Corp. (DX 14359); OPM (DX 14369); Randolph Computer Company (DX 13937); and Tiger Computer; (DX 13938.)

** There is another aspect to IBM's introduction of the 303X systems. As IBM began to market 303X equipment, history seemed to repeat itself: leasing companies with System/370 inventories again discounted their older systems, this time 370s, in competition with the newer 303X machines.

IBM's Significant Wins and Losses Reports show a number of instances where users selected leasing company 370s over IBM 303X machines. For example: DPF 370/155 over proposed 3031 at American Sterilizer (PX 6467, Vol. 5, May, p. 24); Comdisco 370/155-II over 3031 at American Fabrics (id., Vol. 6, March, p. 21); Itel 370/158-1 over 3031 at Winnebago Industries (id., p. 23); Itel 370/168 over 3032 at OAG, Inc. (id., April, p. 23); CMI 370/168-1 over a 3031 at Bausch and Lomb (id., May, p. 24); Comdisco 370/168 over 3032 and Amdahl 470 V/5 at Omaha National Bank (id., September, p. 16); and Comdisco 370/168 over 3032 and Amdahl 470 V/5 at GTE Sylvania. (Id. p. 17.)

equipment worth $14.5 million. (DX 14339, p. 2.) In 1977, it advertised that it had written leases for over $200 million worth of System/370 equipment. (DX 3373.) The Company's revenues rose from $100,000 in 1971 (DX 14211, p. 10) to $37.9 million in 1977. (DX 12185, p. 4.) It also offers leases on 303X and 4300 machines. (DX 11154; DX 14395; DX 11643.) Alanthus offers its equipment on leases ranging from one to six years. (DX 14342; DX 11149; DX 11147; DX 11148.)

Alanthus has attempted to avoid some of the problems that had plagued the lessors of System/360 equipment:

(i) Its depreciation policy for 370 equipment assumed depreciable lives ending on December 31, 1980 (or 1981), regardless of when the equipment was acquired. (DX 14211, p. 5.)

(ii) Costs were "expensed as incurred" rather than deferring them over expected useful life. (DX 14211, p. 8.)

(iii) Leases were generally limited to 370 processors and high-speed memory in order to "avoid the off-rent problem currently being experienced by System/360 lessors with their IBM peripheral equipment, a problem which arises from the fact that such equipment has historically been subject to more rapid technological obsolescence". (DX 14211, p. 5.)

Bank of America

In 1969, internal IBM reports estimated the Bank of America had acquired about $21 million worth of System/360 equipment. (PX 2414, p. 56.)

Through its subsidiaries Decimus Corporation, Decimus Computer Leasing Corporation and Bank of America Leasing Corporation, by early 1977 the Bank of America had acquired a portfolio of over $500 million worth of IBM System/370 equipment. (Rice, Tr. 45245-47.)* This equipment was offered on both a long and short term basis. (Rice, Tr. 45082-83, 45248.)

Ford Motor Credit

Ford Motor Credit Company (FMC), a subsidiary of the Ford Motor Company, began leasing 370 equipment in 1972.** (DX 9099, McKenna, pp. 20-21.) FMC leases on 370 equipment range from one to five years and longer. (Id., pp. 19, 32.) By 1977, FMC had invested approximately $300 million in 370 equipment. (Id., pp. 30, 31.)

As in the case of Alanthus, FMC was apparently concerned that it avoid the pitfalls inherent in some of the business practices followed by lessors of System/360 equipment. Before launching its 370 leasing activities, FMC studied twelve 360

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* In addition, the portfolio included equipment manufactured by Memorex ($3.6 million); Storage Technology Corp. ($53 million) and Four Phase Corp. ($8 million). (Rice, Tr. 45246-47.)

** FMC has also leased equipment manufactured by Honeywell, CDC, Memorex, STC, ISS, Telex and CalComp. (Id., pp. 15-16.)

lessors and identified these problems:

(i) The 360 lessors were paying high interest rates and many decided to invest their rental revenues in unprofitable ventures rather than paying down their debt. (Id., pp. 22-23.)

(ii) They generally depreciated their computer equipment over too long a period--ten years with an assumed 10% residual value.

(iii) Leasing companies encountered problems with their equipment mix which resulted from their inability to re-lease all of their peripheral equipment due to the more rapid technological advancement that had occurred in that area. (Id., p. 24.)

(iv) The features desired by new customers did not always match the features available on equipment coming up for re-lease forcing the leasing companies to purchase new features in order to re-lease the equipment. (See id., p. 25.)

General Electric Credit

General Electric Credit Corp., which entered the computer leasing business in 1971 (DX 14357) reportedly had a portfolio of $600 million of computer equipment in 1978. (See DX 11538.)

OPM

OPM Leasing Services reportedly entered the computer leasing business in 1975. (DX 14371.) It is privately held and reports no financial data, but in 1977 the company advertised that it had "annual sales of more than 1/4 billion dollars" (DX 14370, and is reported to have a System/370 portfolio of "between $300 million and $400 million". (DX 14371.) OPM also offers IBM 303X, IBM 4300 Series, Amdahl, CDC, Univac and DEC machines on short and long-term lease plans. (DX 14396; DX 14398; see also DX 14372.)

During the 1970s many leasing companies were also active as dealers and brokers of used equipment, including 360 and 370 products, as well as non-IBM equipment. Some examples of leasing companies that offered to sell or broker used equipment are: Boothe Computer Corp. (DX 14340, p. 7; DX 13925; DX 14350); Dearborn Computer Leasing Co. (DX 14352 ; DX 13926); General Electric Credit Corp. (DX 14358); Greyhound Computer Corp. (DX 14397); Itel (DX 14473); Finalco (DX 11487; DX 14384; DX 14353); OPM Leasing (DX 14372; DX 14396); and Randolph. (DX 13936.)

In addition, some companies that began largely as brokers and dealers of used equipment expanded into a variety of leasing activities. Perhaps the best known is Comdisco. The company was founded in 1969. Its revenues increased from $1 million in 1970 (DX 14389, p. 2) to $225 million in 1979. (DX 12295, p. 1.) During the latter half of the 1970s, its "revenue growth rate has been more than double that of the industry". (DX 14391, p. 7.) This translates to "compound annual growth rates in revenues and net earnings [of] . . . 36 percent and 55 percent, respectively". (DX 12295, p. 2.)

Comdisco has been, and remains, a broker/dealer of used computer equipment. In 1978, it claimed to be "the world's largest used IBM computer remarketer". (DX 14391, p. 6.) As late as 1979, 67 percent of the company's revenues came from the sale of used computer equipment. (DX 12295, p. 6.)

However, beginning in 1972, the company decided to maintain a portfolio of used IBM equipment for lease. (DX 14390, p. 5.) In 1975, Comdisco had a lease portfolio of $11.5 million. (DX 14390, pp. 5-6.) In the latter half of the 1970s, this portfolio was added to rapidly. By 1978, Comdisco's lease portfolio had increased to over $110* million. (DX 14391, p. 5.) In the same year, Comdisco reported that it had arranged "leveraged" leases for an additional $160 million in IBM computer equipment (DX 14391, p. 10); it also began, in 1978, to offer leases on 303X equipment. (DX 14346.)

Comdisco offers leases ranging "from four months to eight years" (DX 14391, p. 22) through Comdisco Financial Services, Inc., a subsidiary it founded in 1976 to concentrate on leveraged leasing.

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* This amount represents the "cost" of the equipment to Comdisco, a figure presumably well below the original list price. (See DX 14391, p. 5.)

64. <u>IBM System/370 Announcements: 1972-1974.</u> In 1971 and 1972, IBM was making the first volume shipments of the System/370 products announced in the first 18 months of the 1970s. (PX 5779, p. 5; PX 5788A, p. 4.) During these same years, IBM continued to develop newer equipment and programming for the System/370 line.

a. <u>IBM 3705 Communications Controller.</u> In March 1972, IBM announced the IBM 3705 programmable communications controller (JX 38, pp. 1049-57), which was made available under the Extended Term Plan*, as well as under IBM's purchase and rental contracts. (JX 38, pp. 1050, 1055; see Cary, Tr. 101379-80.) The 3705 replaced IBM's earlier 270X line of communications controllers, originally announced in the mid-1960s. (Navas, Tr. 39786-87; JX 38, p. 1049; PX 5693.) Those earlier controllers were not programmable (Withington, Tr. 57738-41) and, hence, did not offer the flexibility of the 3705.

The Commercial Analysis Department in IBM's Data Processing Division wrote in 1970 that: "Because of the inherent limitations of non-programmable units, users are moving rapidly to programmable units to act as preprocessors to large host systems".

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* Announced in March 1972, the Extended Term Plan (ETP) was a two-year rental plan that applied to certain IBM peripheral products and provided for about a 15% discount from IBM's monthly rates. (PX 4529.)

(PX 2545, p. 2.) By 1972, some of the companies offering programmable communications controllers (or front-end processors) included as examples: Comten (DX 2591; DX 2592A; DX 4756A, pp. 9, 40), Honeywell (see p. 994 above), Data General (DX 13886, pp. 3, 5), and Modular Computer Systems. (DX 4756D, p. 17.) About a month before the 3705 was announced, one IBM memorandum stated that there were "a large number of manufacturers with announced products which compete with IBM multiplexors [i.e., the 270X line]". These IBM 270X-compatible multiplexors

> "usually provide attachment of some terminals or line control not offered by IBM in addition to the attachments which IBM provides. Prices are generally somewhat lower than IBM prices for the 2701, 2702 and 2703. In some cases, they are up to 50% lower." (PX 3764, p. 28.)

Similarly, according to Withington, "IBM with the announcement of the 3705 undoubtedly was responding to competitors . . . offering a lower price and an improved function." (Tr. 58563.)

The 3705 could emulate the 270X line or operate in native mode under IBM's new Network Control Program (NCP). (JX 38, p. 1049.) Whether emulating the 270X line or operating in native mode, the 3705 offered several advantages: for example, it was less expensive than the 270X line to the user (Welch, Tr. 75492; Navas, Tr. 39788; PX 5693, p. 1; DX 4312, p. 3); and it could handle a greater number of and more varied communications lines than the 270X. (JX 38, pp. 349-52, 756-58, 1049-51; PX 5693.) And when operating under NCP, the 3705 relieved the CPU of many teleprocessing tasks, supported a wide range of terminals and functions (including the processing and translation of data as it passes from the network to the host processor), and increased the overall flexibility of the system. (JX 38, pp. 1049-51.)

The advantages of the 3705 made the product attractive to users. For example, in early 1975, the U.S. Air Force Accounting and Finance Center explained its procurement of the 3705 by explaining that it was the "least costly competitive selection" among the available options and was deemed "more applicable for evolving requirements at less rental than would be incurred" for multiple non-programmable units. (DX 4312; see also Welch, Tr. 75492.)

In February 1973, IBM announced the 3704, a programmable communications controller that was smaller than, although compatible with, the 3705. (JX 38, pp. 1093-94.)

b. The August 1972 Announcement. In August 1972, IBM made several major product and programming announcements: The System/370 Model 158 and 168 processors with FET memory, virtual memory operating systems for all System/370 processors, and a new method of storage subsystem attachment.

(i) 158/168 Processors: FET Memory. The 158 and 168 processors were designed with advanced semiconductor memory, called Field Effect Transistor, or FET, memory. (E. Bloch, Tr. 91543; DX 1639.) This memory, as developed by IBM, resulted in dramatic performance and miniaturization gains and was offered at a lower price than the core technology used in the earlier IBM 155 and 165 processors. (DX 1639; DX 4740: Evans, Tr. (Telex) 3968.) In addition, because FET semiconductor devices generally require fewer process steps to fabricate and offer higher circuit densities than the bipolar semiconductor memory used on the 135 and 145, they are less expensive to manufacture than bipolar devices, although bipolar circuits tend to be faster. (E. Bloch, Tr. 91483, 91539-43.) Moreover, with those products IBM was able to achieve in its larger processors the advantages of a single integrated packaging technology for logic and memory circuitry resulting in economies of scale of production and packaging, a design goal of the 1960s. (See pp. 907-08 above.)

Significant advantages in price and performance were achieved with the 158 and 168:

(a) The internal speed of the 158 was 20 to 40 percent faster than that of the 155. (PX 4530; DX 4740: Evans, Tr. (Telex) 4029-30.)* With a maximum main memory of two megabytes, the 158 cost less than the 155 (both in purchase price and monthly rental) (PX 4505; PX 4530)

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* In 1973, the U.S. Department of Health, Education and Welfare sought authority from the General Services Administration to procure a 370/158, justified in part by the fact that "the internal performance of the IBM 370/158 is 20-40% faster than that of the 370/155" and "less costly than the present 370/155". (DX 4345; DX 4561.)

giving the customer an effective improvement in internal processing speed per dollar of more than 20 to 40 percent. With main memory of one megabyte, the 158 cost only 15 to 20 percent more than the 155, giving the customer an effective improvement in internal processing speed per dollar of up to 20 percent.*

(b) The 168 offered as much as 30 percent faster internal performance than the 165. (PX 4505; PX 4531; DX 4740: Evans, Tr. (Telex) 4029-30.) With the maximum main memory of three megabytes for the 165 and four megabytes for the 168, the 165 and 168 were about the same price, both for purchase and monthly rental (PX 4505; PX 4531), so that the customer was offered an improvement in internal processing speed per dollar of up to 30 percent.**

A major advantage of FET memory, as implemented on the 158 and 168 processors, was its compactness. The 155 and 165 processors main core memory technology had to be housed in separate boxes, each

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* This comparison does not take into account the additional capabilities and features of the 370/158, including the superior monolithic semiconductor memory and virtual storage, among others. For example, virtual storage could be added to the 155 with a DAT box at an additional purchase price of $200,000 or an additional 10 to 15 percent cost. (See DX 1639, p. 3.) The inclusion of that cost for the 155 would substantially increase the improvement in processing speed per dollar obtained by the 158 in relation to the 155.

** Again, this comparison, like the one for the 158, dces not take into account the additional features of the 168 as contrasted with the 165.

holding up to a half million bytes of memory storage capacity. (DX 4740: Evans, Tr. (Telex) 3980.) Since the maximum memory size of the 155 was two million bytes and the maximum size of the 165 was three million bytes (PX 4505, pp. 2, 4), up to four of these separate memory boxes could be required with the 155 and up to six with the 165. By comparison, the memory circuits for the 158 and 168, at announcement, were one fortieth as large, five times more reliable, used one-seventh as much power and cost one-half as much to manufacture as the core memories used in the 155 and 165 processors. (DX 4740: Evans, Tr. (Telex) 3967-68; DX 9163, p. 20; see DX 9153.) In addition, by 1973, when the 158 and 168 processors were first being shipped to customers, IBM had doubled the density of each memory chip. Thus, as shipped, the 158 and 168 FET memory was only one-eightieth as large as the core memory of the 155 and 165. (DX 4740: Evans, Tr. (Telex) 3974; DX 9163, p. 20; see E. Bloch, Tr. 91547.)

The faster FET memory, at lower cost to the user, contributed to an unprecedented demand for greater main memory capacity on IBM's computer systems. In 1975, Advanced Memory Systems (AMS) estimated that the average amount of add-on memory marketed to users of the System/360 Model 65 was one-half megabyte, "whereas the average add-on for the 370/168 should be 5-1/2 megabytes". (DX 1976, p. 12.) Andreini of AMS testified that, as of the time of his testimony in 1977, he expected maximum memory sizes used in computer systems to increase over the ensuing five years to "32 and 64 megabytes, perhaps more". (Tr. 48722-23.)

(ii) Virtual Memory Operating Systems. Another major element of IBM's August 1972 announcement was virtual memory. The new processors announced in the summer of 1972, as well as all earlier-announced System/370 processors, could utilize the new virtual memory capability.* (DX 1640; PX 4530; PX 4531; PX 4533.) Virtual memory, or as it is sometimes called, virtual storage, is a combination of hardware and software which provides EDP users with an apparent main memory capacity substantially greater than the actual main memory capacity of their systems. (McCollister, Tr. 9673; Enfield, Tr. 20774-76; Case, Tr. 73668; DX 4740: Evans, Tr (Telex) 3942-45.) Evans of IBM explained it this way:

> "Now, the thing about . . . virtual memory, is that it's an extension through the architecture of the machine, the thing that controls the machine, such that is [sic] combines the auxiliary storage, in our case, disk files, with the main memory, so that it gives the appearance to the user, the programmer, that he has, in the case of System 370, 16,000,000 bytes or characters of memory at his disposal.
>
> "And, furthermore, the machine automatically handles the overhead of memory allocation. The programmer doesn't worry about just where to store this data, and just how to fit it in the space he has available; he lets the machine do that for him, and the machine takes the responsibility for storing, coding and storing the information and bringing the instructions and data to the central [processing unit] when the user's program needs it." (DX 4740: Evans, Tr. (Telex) 3944.)

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* As noted above, for the System/370 Model 155 and 165 processors announced in June 1970, IBM announced Dynamic Address Translation (DAT) hardware which permitted those processors to function as virtual memory machines. The 135 and 145 processors, announced in 1970 and 1971, did not require additional hardware to make use of IBM's new virtual memory software. (PX 4527; PX 4528; PX 4532; PX 4533; DX 1640.)

As Evans stated, virtual memory made a System/370 processor appear to the user as if it has 16 million bytes of memory. In fact, the processor could have had as little as 130,000 or less actual bytes of memory. (DX 4740: Evans, Tr. (Telex) 3944-46.) As we have discussed above, it was Evans who altered the 370 product plans to include virtual memory. (See above, pp. 914-15.)

IBM's virtual memory announcement of 1972 was not the first announcement of virtual storage by an EDP vendor. Virtual storage in various forms had been implemented during the 1960s by Burroughs, GE, CDC, RCA and others--including IBM. (Weil, Tr. 7290-91; Withington, Tr. 58529; DX 4740: Evans, Tr. (Telex) 3952-53.) Yet these early virtual memory offerings encountered difficulties. For example,

(a) Weil of GE testified that "[t]he dynamic relocation facilities GE had on the 625 and 635 were inadequate for virtual storage applications". (Tr. 7288.)

(b) Rooney of RCA testified:

> "Timesharing Operating System was a form of virtual memory system that had a great deal of functional capability to offer, that was new and unique in the marketplace, but its reliability in performance was extremely poor and we had not achieved a high degree of reliability with that system while I was at RCA [i.e., up to March 1972]." (Tr. 12132-33, 11688.)

Rooney also testified that, as of approximately 1970, RCA had fifty to sixty virtual memory customer installations. With respect to those installations he testified:

"The performance of the installed systems were poor and therefore, we were making improvements in releases and we had one release that was going to be applied to the RCA 7 Series and that was due to come out in 1971, early in the year . . . and that was delayed." (Tr. 12133.)

(c) IBM's virtual memory announcement built upon its experience derived from its System 360 Model 67/TSS program of the 1960s. (Case, Tr. 73577-79; PX 2500; DX 4740: Evans, Tr (Telex) 3947-51.) In that program, IBM also encountered unexpected difficulties and even considered abandoning it entirely in late 1966. (See p. 435 above.)

The difficulties and risks of continuing the Model 67 program and of pushing "relocate" hardware and programming technologies were in large measure vindicated by the quality of IBM's virtual storage announcements in 1972. (Case, Tr. 73577-79; DX 4740: Evans, Tr. (Telex) 3953.)

(iii) <u>The New Attachment Strategy.</u> IBM's August 1972 announcement also included a new disk control unit, the 3830 Model II and an optional Integrated Storage Control (ISC) feature for the 145, 158 and 168 processors which permitted attachment of IBM's 3330 disk drives. (JX 38, p. 1072; PX 4530; PX 4531; PX 4533.) IBM also announced an Integrated File Adapter (IFA) to handle 3330 disk drives on Model 135 processors. (PX 4533.)

In these disk control hardware announcements, IBM retained the interface that had been used on System/360, first announced in 1964. (Case, Tr. 74080-81; DX 3651B.) Hence, IBM designers, or for that matter, designers of competitive plug-compatible disk subsystems could continue to design products to attach to that channel interface. An advantage of the "new attachment strategy", however, lay in its creation of a single disk drive-to-control function interface for new disk products and processors, whether those processors are used with integrated controllers or with separate control units. In the past most IBM disk drive products had different and unique interfaces and thus required different control units. (Case, Tr. 74120-25; Haughton, Tr. 95017-19.) The new attachment strategy created a single interface that permitted the use of a single disk control unit, the 3830 Model II, for the 370 disk drives. (Case, Tr. 74033-36; Tr. 74101-02; Tr. 74120-25; Haughton, Tr. 95024.) The new single interface was also used in the variety of new integrated controllers for IBM 370 processors. (Case, Tr. 74101-02; DX 3651B.) Hence, IBM's 3330 and the later announced 3340, 3344, 3350 and 3370 disk drives and the IBM 3850 Mass Storage subsystem all utilized the new interface. (DX 9405, pp. 1055-61, 1387-88; see pp. 1055-56, 1060-65 below.)

c. IBM System/370 Models 125 and 115. In October 1972, IBM announced the System/370 Model 125 and, in March 1973, the System/370 Model 115. (PX 4534; PX 4537.) These were smaller members of the 370 family, offering virtual memory and monolithic memory technology. (Id.) The 125 provided approximately 2 to 4.5 times the internal speed of a System/360 Model 25 and 1.3 to 3 times the speed of the Model 22. (PX 4534, p. 1.) The 115 offered approximately 1.5 to 3 times the internal speed of a System/360 Model 25 and 1 to 1.5 times the speed of a System/360 Model 22. (PX 4537, p. 1.)

In large measure, the significance of these smaller members of the System/370 line lay in the extent to which IBM provided for them advanced systems control programming and upward 370 programming compatibility. In the System/360 era, cost/function trade-offs at the low end of the line required elimination of some functions and of some compatibility with the larger processors. (Weil, Tr. 7081-83; Case, Tr. 73384-85, 73396.) This was true for the IBM Model 20, for example. (JX 38, pp. 694-705.) In contrast, the 115 and 125 were compatible with the larger 370 processors. (PX 4534; PX 4537.)

At the same time, IBM announced its 3330 Model 2, a one-spindle version of the 3330 and a new 3340 disk drive for the Model 115. (JX 38, p. 1076; see pp. 1055-56 below.)

d. Term Lease Plan. In March 1973, IBM announced the Term Lease Plan (TLP). TLP was an optional four-year, fixed term lease available for virtual memory System/370 processors. It eliminated additional use charges on the processors and memory, offered users 48 months of price protection, and offered users the ability to accrue rentals up to 50% toward the purchase price of the processor. (DX 14138, p. 1.)

TLP was IBM's first longer term lease on processors, although such terms and conditions were already common among IBM's system and leasing company competitors. (See, e.g., Spitters, Tr. 54432-33; DX 4355, p. 21.)

In June 1976, IBM modified TLP to offer roughly a 9% price reduction from the monthly rental charge under the plan. (DX 9405, pp. 412-19.)

e. <u>1973 Disk and Tape Subsystem Announcements.</u> In 1973, IBM made three major product announcements in computer storage: the 3420 Models 4, 6 and 8 tape drives (internally known as "Birch"), the 3340 disk drive (internally known as "Winchester") and the 3330 Model 11 disk drive ("Iceberg"). (JX 38, pp. 1104-05; PX 4538; PX 4539.)

(i) <u>"Birch".</u> The 3420 Models 4, 6 and 8 tape drives, announced in March 1973, represented nearly a four-fold increase in storage density over any tape drive in the computer industry. (JX 38, pp. 1104-05.)

The recording method used by IBM to achieve this increase in storage density, known as Group Code Recording (GCR), was a major innovation:

(a) Mr. Brown of Control Data Corporation testified that GCR "is far more advantageous to the user [than prior methods]. It's a far more reliable approach in its ability to detect errors". (Tr. 51676-77.)

(b) The management of Storage Technology Corporation had a similar assessment of the advantages of the GCR format.

(See DX 2110, p. 4.)

(c) Honeywell also believed that the 3420-4, 6, 8 offered "significant technical advances" to users, including its four-fold density increase and "[a]dvanced error correction algorithms". (DX 145, p. 4-8.)

With this announcement, IBM completed the tape development program it started in the 1960s. (See pp. 885-98 above.)

(ii) "Winchester". Also in March 1973, IBM announced the 3340, or "Winchester", disk drive. (PX 4538.) The 3340 was "a high performance, intermediate capacity disk storage" device that "introduce[d] a new concept in storage media, the 3348 Data Module. . . ." (Id., p. 1.) The new data module combined in one sealed unit both the disk surfaces and the read/write heads. (Haughton, Tr. 94918-21; PX 4538, p. 1; see DX 9344A.) In disk drives with removable disk packs, there was danger of errors caused by different packs being used on different drives; costly mechanisms and tolerances had to be built into the equipment to prevent such errors from occurring. (See Haughton, Tr. 94833-42, 94864-72; DX 9340A.) The use of the data module gave the disk drive greater reliability at lower cost, because the same disk heads would always read and write data on the same disk surfaces and also reduced the danger of "contaminating" the disk surface. (Case, Tr. 72746-47; Haughton, Tr. 94924-25.) In addition, the 3340 featured a new low mass read/write head assembly which Haughton believed was Winchester's "most significant innovation" (Tr. 94990): it eliminated the need for much of the hardware that had previously been used to keep heavier heads from coming into contact with and destroying disk surfaces. (Haughton, Tr. 94990; see also Tr. 94917-18, 94877-78.)

Brown of Control Data testified that his company's examination of the 3340

> "convinced us that the technology was a very sound one, and that the product appeared to offer reliability improvements over other products which had utilized 3330 type technologies.
>
> "In general terms, it appeared that the product was roughly twice as reliable from a user viewpoint, and therefore, we began to explore various ways in which we might implement that technology in products of our own choosing." (Tr. 51304-05.)

Navas of Memorex stated:

> "The 3340 offered higher performance and less cost for a given amount of capacity to a user than the 2314, 2319 series disk drives, and hence would be more attractive to users of IBM's System 370 to which either product could attach." (Tr. 41439; see also Withington, Tr. 58291.)

According to Haughton, the Winchester development program began in early 1969 and was aimed at achieving a relatively low-priced disk drive combining the advantages of disk removability with some of the engineering advantages associated with fixed disk files. (Tr. 94912-15, 94920-21; see pp. 903-04 above.) However, the Winchester was not ready for announcement until March 1973. (See p. 1055 above.)

(iii) <u>"Iceberg".</u> In July 1973, IBM announced a double capacity version of its 3330 disk drive, the 3330 Model 11, with 200 million bytes of storage per spindle, as compared with 100 million on the original 3330. (JX 38, pp. 971-73; PX 4539.) The density of the tracks was almost doubled from 192 tracks per inch on the 3330 to 370 tracks per inch on the 3330 Model 11. (Haughton, Tr. 94995.) IBM was able to increase the recording densities on the 3330 Model 11 because of its development of a new disk coating process called "zapping". (Haughton, Tr. 94993-95.) Navas of Memorex stated:

> "[IBM] changed the media and they changed the head flying height [for the 3330 Model 11]. . . . The new media was smoother, had a thinner coating, had inherently better performance, but was basically designed to allow a head to fly lower." (DX 1482B, p. 46.)

The 3330 Model 11 product was the result of an IBM development program begun at about the time of the original 3330 announcement--mid-1970. In July 1970, J. K. Clemens of IBM's Systems Development Division facility in San Jose, California, called for implementation of the "Iceberg" program, which he described as

> "an extended capacity Merlin Facility . . . achieved by increasing the bit and track density of the basic Merlin Facility. Technological improvements such as reduced flying height, narrower recording gap, new encoding methods, and improved defect handling are needed." (DX 3260, pp. 1-2.)

Despite the recent vintage (1970) of the 3330, itself a significant innovation and price/performance improvement, IBM was compelled to improve on that product's performance as rapidly as possible. A February 1971 review of peripherals by IBM's Management Committee reported that:

> "In the disk area, there is an apparent one year acceleration of a Merlin type plug-for-plug file [by

competition and] work is going on in San Jose to both accelerate and enhance the Iceberg program." (PX 3154.)

In 1970 through 1973, as we have discussed, there were numerous competitive disk subsystem developments. Vendors, including Ampex, CalComp, CDC, Marshall, Memorex and Telex, announced double density versions of the 2314. (DX 4556, p. 3.) Companies also announced 3330 equivalents. These included: Memorex, Century Data Systems, Potter, Telex, CDC, Ampex, Itel and STC. (DX 1437; DX 4756B, p. R-96; DX 4756C, pp. 70, R-150, 168, 172; DX 4556, p. 3; DX 9043, p. 58.) STC, Memorex and CalComp delivered 3330-compatible products within eight months of IBM's first 3330 Model 11 shipment (DX 2377A), and Itel (through ISS) went into full production and shipment within one year. (DX 2231, p. 15; DX 2235.)

f. <u>IBM 3600 Terminal Subsystems.</u> During the second half of 1973 IBM announced a series of terminal subsystems, the IBM 3600, 3650 and 3660. (DX 13960; DX 13961; DX 13962.) These subsystems were designed to perform input and output as well as a range of additional storage and processing functions commonly needed in specific industries: banking and other financial institutions, retail stores, supermarkets, and insurance companies. (<u>Id.</u>) Each operated as part of IBM 370 computer systems. (<u>Id.</u>)

These terminal subsystems were IBM's first major "industry oriented" terminals since the announcement of the 3670 brokerage communications system in September 1971. (JX 38, p.

1025.) The subsystems operated to bring the power of a System/370 processor directly to the point where a customer's data are created, whether its source is a bank deposit or a supermarket purchase. Through their use, information could be captured, translated into machine-readable form, processed and stored for immediate processing, as well as for subsequent additional processing. (DX 13960; DX 13961; DX 13962.) The supermarket terminal, for example, was abl to read data (prices) directly off grocery items marked with the Universal Product Code, compute totals, print out a sales slip and forward information to the terminal controllers for storage and processing in those controllers or for entry into larger processors located elsewhere. (DX 13962.)

Other companies introduced industry oriented terminal subsystems, with substantial remote processing capability, at the time or before IBM announced its 3600 line. For example:

(i) In 1970, NCR introduced its 280 Retail System, which included an "intelligent" terminal, input/output equipment, data storage and communications hardware, and software permitting the subsystem to operate as part of NCR computer systems. (See p. 998.)

(ii) In 1971, NCR introduced its 270 Financial System to perform on-line bank teller transactions, linked directly to central processors. According to NCR, the 270 was, at the time, the most advanced system available for customer transactions in savings institutions and commercial banks.

(DX 341, p. 3.)

(iii) In 1973, National Semiconductor was offering its Datachecker system, which was a point-of-sale terminal system for the retail industry. It provided electronic registers and scales for each checkout stand plus a micro-computer and disk storage. (DX 12604, p. 10.)

g. System/3 Model 15. In July 1973, IBM announced the System/3 Model 15, a more powerful model of the earlier announced System/3 computers. (DX 8073, p. 30; see p. 911 above.) The Model 15 offered a variety of software capabilities, including RPG, COBOL, FORTRAN and a Communication Control Program for handling communications applications. (DX 8073, p. 30.) It also offered greater on-line disk capacity. (Id.) By 1973, IBM had added control programming to its System/3 line to permit those systems to be used not only as stand-alone systems but also to be linked to other processors in a larger System/370 system. (DX 8073, p. 27.)

h. IBM 3850 Mass Storage Subsystem. In October 1974 IBM announced the 3850 Mass Storage Subsystem, for use with System/370 processors above the Model 135. (JX 39.) The 3850 is a "mass" storage device because it is capable of storing, under the control of a single control unit, 472 billion bytes of data, that can, in turn, be accessed by as many as four different System/370 processors at any one time. (Id.) That amount of data, on-line and available to processors through a single control unit is a manifold improvement in the amount of on-line data available. By comparison:

(i) The IBM 2314 Direct Access Storage Facility, announced in 1965, held over 200 million bytes of data and was, in its day, at the state of the art. (Beard, Tr. 8575; McCollister, Tr. 9370; Case, Tr. 72742-73; JX 38, p. 439; PX 1967.)

(ii) The IBM 3330 Model 11 disk subsystem, announced in 1973, a year earlier, was capable of storing about 6.4 billion bytes of data under the control of a single control unit. (PX 4536, p. 1; PX 4539, p. 1.)

(iii) The IBM 3420, Model 4, 6 and 8 tape subsystem, also announced in 1973, was capable of storing about 1.3 billion bytes of data under the control of a single control unit.*

The 3850 mass storage subsystem uses an IBM 3330 disk storage device in combination with innovative "honeycombs" of new magnetic tape media, which are accessed by electro-mechanical devices and read onto the disks for processing. (Case, Tr.

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* That calculation is made as follows: The "Birch" tape drive featured a storage density of 6,250 bytes of data per inch of tape (JX 38, pp. 1104-05), or 75,000 bytes per foot of tape; on a standard tape of 2,400 feet, the total storage capacity is 180 million bytes; since each controller can handle eight tape drives, the maximum storage capacity handled by one controller is 1.44 billion bytes. After deducting capacity lost because of gaps on the tape between blocks of data or "records" (known as the "inter-record gap"), the approximate actual storage capacity per subsystem is 1.3 billion bytes.

73492-93; DX 3621; DX 3630.) Aweida of STC explained that the 3850

> "consists primarily of two subsystems. One is storage facility, which is based on magnetic recording on strips of tape and [the second is] a disk subsystem. So the mass storage combined some of the benefits of tape and the benefits of disk together." (Aweida, Tr. 49711.)

According to Aweida, "the main benefit of having a mass storage or 3850 is the ability to have available under computer control a large amount of information". (Tr. 49711-12.) The information is "staged"--i.e., it is taken from the magnetic strips within the 3850's cartridges to a disk subsystem and then from the disks to the CPU. (Id.) In this way, vast amounts of information can be stored and retrieved under the control of the computer within seconds (Aweida, Tr. 49711-13), without the need for anyone to select, mount and unmount reels of tape.

The advantages of the 3850 can be significant. For example, Welch of Chemical Bank testified that use of the 3850 "will allow us to reduce our library of 27,000 tapes, we believe, to approximately 5,000". (Welch, Tr. 75254.) Similarly, McGrew of Union Carbide testified that his organization was considering acquiring IBM's mass storage system largely because it would be possible to put onto that system "all of the data" being stored on 40,000 magnetic tapes in one of the company's computer centers. (Tr. 77430-31.)

Within a year after IBM's announcement of the 3850, CDC announced its 38500 equivalent to IBM's 3850 mass storage unit, capable of storing up to 16 billion bytes. (PX 4762, p. 211.) CDC marketed the 38500 to users of IBM System/370 computer systems, on an OEM basis to other systems manufacturers, and for use with its own computer systems. (PX 4762, pp. 193-214.) As described by Case, the CDC machine "is different than the IBM machine in that it does not use the rotating head diagonal stripe recording mechanism . . . [and] it does not automatically transfer the information from the magnetic tape to a magnetic disk before it's used by the central processing unit, and then automatically take it back from the magnetic disk to the magnetic tape for the benefits of low cost storage after its use". (Tr. 72847.)

Other competitors also offered "mass storage" devices to replace IBM's 3850 or other IBM tape and disk subsystem products. For example:

(i) In October 1973, STC announced its 8000 Series "Super Disks", with a capacity of 800 million bytes of information per module. (Aweida, Tr. 49342-45; PX 4701, pp. 5, 29, 31; PX 4702, p. 12.) STC marketed the "Super Disk" in "combination" with its high performance tape subsystems as an alternative to IBM 3850 and other mass storage devices. (Aweida, Tr. 49698.)

(ii) In 1974, CalComp began marketing an "Automated Tape Library" after acquiring the Xytex Corporation, the company that developed the device. The "Automated Tape Library" permitted the automatic mounting and dismounting of magnetic tape reels on as many as 32 tape drives under the control of a host computer. The library could store up to 7000 reels of tape. (Aweida, Tr. 49695-97; PX 5585, pp. 5, 22-23; PX 5586, pp. 6, 12-13; PX 5587, pp. 7, 12; see also DX 11270.)

(iii) Much later, in June 1979, the trade press reported that a joint venture of Japanese firms had introduced a mass storage system "designed to replace the IBM 3850". (DX 14361.) As reported, that system consisted of a mass storage device, a disk control device and a disk drive. (Id.)

VII. EXPANSION AND ENTRY OF COMPETITORS

65. Introduction. IBM's continuing improvements in its System/370 line in 1972, 1973 and 1974 added competitive challenges to other suppliers in the computer industry. Existing competitors, however, were quick to announce new, better price/performance products and services of their own. And those suppliers, together with an influx of new companies, were also offering computer customers increasingly attractive new alternatives for doing their data processing work. As will be discussed below, the computer industry in the middle and late 1970s was characterized by a profusion of these newer alternative products and services from new and old suppliers, including:

(i) so-called "minicomputer" systems, which, by the mid-1970s were often the functional equivalent of the medium and large-scale computer systems offered by the "traditional" systems manufacturers, including IBM's System/370 computer systems.

(ii) "intelligent" terminal equipment and "distributed data processing" equipment, which by the mid-1970s provided users with attractive, cost-effective methods of "off-loading" processing, storage and input/output from central site computer equipment and of configuring their computer systems in many varieties of "decentralized" or "distributed" system designs.

(iii) increasingly sophisticated input and output equipment that permitted users by the mid-1970s to collect, store, process and display data at the point where the data was to be collected and used, rather than relying on the "main" computer room as was the case in the 1950s and 1960s.

(iv) computer networks, fashioned and run by computer services companies, like ADP, Xerox and General Electric, offering services and hardware, too, to perform a variety of data processing tasks for potential or current computer users.

(v) plug-compatible central processing units, which, beginning with Amdahl in 1975, led to the entry of a number of additional competitors which replaced IBM CPUs in growing numbers.

(vi) expansion of common carriers, especially AT&T, which offered data processing products combined with communications capability to take advantage of the convergence of the two fields.

(vii) foreign competitors, especially the Japanese, with plug-compatible CPUs and systems, smaller computer systems, disk drives and other types of EDP products.

66. Growth of Competitors: 1974-1980. The period from 1974 to the present in the computer industry has witnessed a rapid expansion of existing competitors and the entry and growth of a variety of new suppliers, many with sophisticated and highly successful product and service offerings. The expansion and entry appears both to have been spurred by a continuing increase in demand for data processing products and services and to have itself contributed to that increase in demand.

The Census II depositions taken in this case do not provide EDP revenue data beyond 1972. Nonetheless, two sources are available that provide some information on the computer industry's growth in the latter half of the 1970s, and the sources point to a continuing if not accelerating high rate of growth:

(i) The United States Bureau of the Census collects data under its standard industrial classification (SIC) code 3573 for "electronic computing equipment" (not including software or services). In that industry classification, the value of shipments of computer hardware products produced in the United States* increased from $7.6 billion in 1974 to $11.8 billion in 1977, the last year for which data have been published, an increase of approximately 57 percent.

(ii) Beginning in 1976, the trade press publication,

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* As reported in U.S. Department of Commerce, Bureau of the Census, Current Industrial Reports, Office, Computing, and Accounting Machines, MA-35R(77)-1, (issued November 1978), under product class codes 35731, 35732 and 35734. (DX 14309, p. 3.)

Datamation, has published annually estimates of total data processing revenues for the preceding year for the "Top 50 U.S. Companies in the Data Processing Industry". (DX 13657; DX 13658; DX 13659; DX 13660; DX 13945.)* Based on these estimates, the Top 50 companies' worldwide data processing revenues grew from "something over $22.2 billion" in 1975 to $36.1 billion for fiscal year 1978, a 62.6 percent increase in only three years. (DX 13657, p. 1; DX 13660, p. 1.) 1979 data processing revenues for the Top 50 firms were estimated to have increased to about $42.7 billion, 18.3 percent over 1978. (DX 13945, p. 7.)

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* DX 13945, the July 1980 Datamation report, expands the list to the "Top 100". On methodology, the 1980 report states, as did the previous ones:

> "We have defined data processing revenues as general purpose data processing products and services during calendar 1979. Explicitly excluded are: communications devices such as modems, multiplexors, PABXs; regulated communication services; standalone equipment without functional connections to dp systems, such as general office equipment, electronic and mag card typewriters, and electronic cash registers; instrumentation; and dp supplies with the exception of magnetic media for disk and tape drives. Standalone equipment to be included must be programmable and all peripherals that attach to a dp system are included ." (DX 13945, p. 6, emphasis in original.)

67. <u>1960s Competitors</u>

a. <u>Burroughs.</u> Burroughs' financial results reflect a continuation of growth that began in the 1960s. Revenues of the company's Business Machines Group, whose activities include domesti marketing of EDP products and services, grew from $483 million in 1972 to $1.2 billion in 1979. (DX 3292A, p. 6; DX 12291, p. 6.) Total corporate revenues climbed from slightly over $1 billion in 1972 to $2.8 billion in 1979. (DX 3292A, p. 2; DX 12291, p. 3.)

Burroughs achieved these results in an industry that, it said, was characterized by "new generations of products, expanding markets, rapid advances in technology, and a changing competitive structure." (DX 12289, p. 4.)

In 1973, Burroughs reported that its B1700 "small scale computer systems", introduced in 1972 (see p. 982 above), had "achieved a very high level of customer acceptance in a wide variet of installations throughout the world." (DX 3292A, p. 14.) The B1700 systems could be used "as self-contained systems or as distri buted data processing systems in an on-line communications network. (<u>Id.</u>)

In 1973, Burroughs introduced the B700 series of "small scale computers", which according to the company "fits between our B1700 series of small-scale computer systems and the Series L business mini-computers." (<u>Id.</u>, pp. 14-15.)*

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* Burroughs stated that its Series L "minicomputers", introduced in 1969 (see p. 982 above), permit small businesses to implement EDP capability and "are also in wide use within larger organization

In 1974, Burroughs stated:

> "Small computer systems and business mini-computers represent an important marketing opportunity for our Company. They cover a very broad and fast growing sector of the computer market which extends from smaller businesses entering electronic data processing for the first time, to large organizations requiring decentralized data processing capabilities." (DX 3292A, p. 14.)

In 1976, Burroughs further expanded its small computer line with the introduction of the B80--"a fully featured general purpose system whose price range begins at minicomputer levels." (DX 12288, p. 15.) Burroughs stated that,

> "The B80's appeal is universal. It is an ideal system for smaller firms with basic data processing and reporting needs. The B80 has equally strong appeal for very large organizations with smaller operations, and which need to equip these operations with small, self-contained computers or to link them into a decentralized data processing network." (DX 12288, p. 15; see DX 12289, p. 15; DX 12290, pp. 8-9.)*

Still further announcements were made in 1979: the B1900 and B90 series of computers, part of Burroughs' newly announced 900 family. According to Burroughs, "[t]he B1900 Series serves what is

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that wish to provide localized data processing capabilities to their operating units". (Id., p. 15; DX 12287, p. 14.) Series L systems can also be converted to "terminal computers by the addition of a data communications module. As terminal computers, they can communicate with other terminals and with central computer systems." (DX 484, p. 15.)

* In 1978, Burroughs reported that it had experienced "strong order growth" for its new "small" systems highlighted by multiple unit orders from such firms as Barclays Bank in the United Kingdom which ordered 500 B80s along with 1000 S400 document processing systems, and Pharmaceutical Data Services, Ltd., of Alberta, Canada, which ordered 100 B80s". (DX 12290, pp. 8-9.)

now the most expansive segment of the computer market, one that has been stimulated by the many organizations moving into distributed processing, as well as by those that need small but powerful stand-alone computers." (DX 12291, pp. 11, 13.) Burroughs observed in its 1979 Annual Report that customers for its "small systems", including the B90, B1800 and B1900 Series, "range from small businesses, banks, credit unions, and educational institutions, to extremely large organizations with distributed processing requirements." (DX 12291, p. 17.)

Between 1975 and 1980, Burroughs also maintained a rapid pace in the introduction of new "medium and large-scale" computer systems. In 1975, Burroughs introduced the initial members of its "800" family -- the B2800, B3800 and B4800. (DX 12287, p. 2.) According to Burroughs, these new systems offered 1.5 to 4 times the power of B2700, B3700 or B4700 systems. (Id., p. 13.) In 1976 and early 1977, Burroughs completed the introduction of the "800" family with the announcement of the B6800 and B7800, which offered 2 and 2.5 times the performance of the B6700 and B7700 systems, respectively. (DX 12288, p. 13.)

In mid-1977, Burroughs introduced two new models of the B3800, reportedly "designed to undercut IBM's 370/138." One model, expandable to 1 million bytes of main memory, featured new chip technology; the other, ability to be configured into dual-processor systems. (DX 14233.)

In 1978, Burroughs announced new models in the B2800, B3800 and B4800 series, which featured "engineering enhancements to central processors, increases in basic memory capacities, and new software capabilities. [Burroughs] also announced new system and communications processors which increase the performance of [its] medium-scale computers when serving as network 'host' systems." (DX 12290, p. 9.)

The following year, 1979, Burroughs introduced an entire new "family" of computers, the '900', initially consisting of the B90, B1900, B2900, B3900 and B6900 series. (DX 12291, p. 11.) The B3900 was capable of supporting from 2 million to 5 million bytes of main memory and reportedly offered approximately the same performance as the IBM 4341 processor, announced in January of that year. (DX 14235; see p. 1330 below.)

b. <u>Control Data Corporation.</u> The revenues from Control Data's "computer business"* increased by over $1.3 billion in the last 7 years of the 1970s: from $948.2 million in 1973 to nearly $2.3 billion in 1979, a compound annual growth rate of over 15.9 percent. (DX 306, pp. B, 20; DX 12304, p. 2.)

CDC achieved this success in the face of what its management saw as substantial competition. Norris testified that in marketing its computer systems, peripheral equipment and data services, CDC's competitors included: IBM, Honeywell, Univac, Burroughs, Xerox, perhaps "as many as a thousand" companies offering data services, 50 to 75 minicomputer manufacturers--whose products represent alternatives for customers interested in larger systems, data services or minicomputers--and between 20 and over 50 terminals manufacturers. (Tr. 5629, 5996-99.)**

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* In 1979 CDC described its computer business as follows:

> "The principal products and services of the Computer Company are computer systems, peripheral equipment and computer services. Our large-scale computer systems are relied upon worldwide for high-volume data processing and communications. Control Data peripheral equipment is used in our systems and sold to other computer manufacturers for resale with their products. The company's computer services include a broad range of consulting, education services and data services as well as maintenance services for computers and similar equipment." (DX 12304, p. 1.)

** Gordon Brown testified in 1977 that competition in the terminals area "can be extremely severe". (Tr. 51559.) He stated that the number of companies competing in marketing terminals against CDC and IBM was "[m]ore than I can name sitting here. A great number of companies." (Tr. 51559-60.)

(i) Peripherals. In the 1970s, CDC's peripheral products business was the fastest growing part of its EDP operations. CDC's revenues from the marketing of peripheral products nearly tripled between 1975 and 1979, growing from approximately $317 million to about $909 million. (DX 12597, p. 2; DX 12304, pp. 2, 6.)

CDC markets peripheral products as part of its own computer systems, directly to users of computers manufactured by others, and on an OEM basis to other computer equipment manufacturers who in turn market them to end users. (DX 2435, p. B.) Much of CDC's end-user peripherals business in the 1970s involved marketing compatible replacements for IBM peripherals. In 1977, CDC reported that it had installed IBM-compatible products at more than 1300 IBM user installations. (DX 12302, p. 13; see also DX 2269, p. 2; DX 11360.) CDC's OEM peripherals business grew from 215 customers in 1973 to 720 in 1977. (DX 12302, p. 11.) For 1977, CDC reported:

> "Sales of peripheral equipment to other computer manufacturers (OEM's) were very strong and established records that exceeded expectations. Control Data offers a total range of products from small 'floppy disks', used in terminals and minicomputers, up to large capacity disk files that are used in medium to large computer systems. Much of this successful expansion in OEM shipments is due to the very rapid growth in the minicomputer industry. Control Data makes peripherals for all of the 25 largest minicomputer companies in the United States." (Id., pp. 11, 13.)

CDC's peripheral products have included: disk drives and controllers, tape drives and controllers, printers, card readers and punches, terminals, data entry systems, mass storage devices, optical character recognition devices and add-on memory. (DX

12597, p. 4; see DX 2781A; pp. 986-87 above.) CDC has acquired a number of these products from joint ventures formed in 1972 and 1975. In 1972, CDC and NCR, later joined by ICL, formed Computer Peripherals, Inc. (CPI) to manufacture card, tape and printer equipment. (Lacey, Tr. 6704-07; DX 12597, p. 4.) In 1975, CDC and Honeywell formed Magnetic Peripherals, Inc. to "develop and manufacture rotating mass memory products". At the time of its formation, MPI was 70 percent owned by CDC and 30 percent owned by Honeywell. (Norris, Tr. 5655-57; DX 12597, pp. 4, 17.)

CDC's peripheral products included these:

(a) Add-on memory for IBM System/370 Model 135 through 168 and 303X, manufactured by AMS and Memory Technology Corporation. (G. Brown, Tr. 51456-58; DX 11345; DX 11366; DX 12488; DX 13259; DX 13266.)

(b) IBM plug-compatible 2314-type disks. Brown testified that versions of these devices were also used on CDC's own systems and were marketed on an OEM basis to SDS, ICL, CII, Siemens, XDS, Toshiba, Melco, Singer and "[p]robably another fifty customers taking small quantities." (G. Brown, Tr. 51433-37.)

(c) IBM plug-compatible 3330-type disks, including single and double density versions. Norris testified that a "quite similar" device was also marketed with CDC systems and essentially the same disk drive was marketed on an OEM basis. (Tr. 6023-24, 6027.) Brown testified that versions of CDC's systems and on an OEM basis. OEM customers included Siemens, ICL, NCR, Honeywell "and a number of other systems houses." (Tr. 51267-69.)*

(d) A disk subsystem, the 33801, which could be used either in 3330-type or in 3350-type--that is, offering the storage capacity of the IBM 3330 or 3350--at "substantial cost savings". (DX 2338A, p. 3; G. Brown, Tr. 51601-03, 52662-63; see also Withington, Tr. 56445-47; DX 11354.) A double density version, the 33802, was announced in 1978. (DX 13270; see also DX 11367.)

(e) An equivalent to IBM's 3850 Mass Storage System, capable of storing up to 100 billion bits of data on magnetic tape cassettes. (DX 12597, pp. 1, 4; G. Brown, Tr. 51453-55, 51647-53; see also DX 13263.) In 1978, CDC announced "a version of its IBM plug-compatible mass storage system for use with the CDC 170, 70 and 6000 computer systems". (DX 14241.)

(f) A plug-compatible replacement for IBM's 1403N1 printer. (DX 11342.) In 1979 it was reported that CDC had announced a 2000 lines-per-minute printer and controller for users of IBM systems. This printer subsystem was said to be

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* Norris testified that between 1968 and 1975 CDC's "Rotating Memory Equipment", which includes disks and drum memory, was sold to: Adage, Bell Telephone Laboratories, Bunker Ramo, CDC users, C. Itoh, CII, Collins Radio Co., Comcet, EAI, Electrologica, EMR, Fairchild, General Electric, Honeywell, IBM users, ICL, Leasco S & R, Marconi, Medec, NCR, Olivetti, PCI, Philips, Promodata, RCA, Raytheon, Redcor, A/S Regnecentralen, SAAB, SDS, Systems Engineering Labs., SEL, Siemens, Telefunken, Toshiba, Tracor Computing, Trend, UCC, Univac, Univac users, Varian, Western Union and Xerox Data Systems. (Norris, Tr. 6023; DX 297.)

manufactured by CPI, which has manufactured more than 3,000 similar printer subsystems for use with other manufacturers' computer systems. (DX 14242.)

(g) A range of disk storage units, marketed on an OEM basis, featuring capacities from 40 million to 300 million bytes. (G. Brown, Tr. 51327-28.) At the end of 1979, it was reported that CDC had shipped its 50,000th such device and that this product line had contributed over $500 million in revenues to CDC since 1974. (DX 14102.)

(h) A line of plug-compatible peripherals, introduced in 1978, including disks, printers, terminals and storage module drives, for IBM's Series/1 computers. (DX 11365.)

(ii) Data Services. In 1973, as a result of the settlement of its lawsuit with IBM, CDC acquired The Service Bureau Corporation (SBC) from IBM. (Norris, Tr. 5651-52, 5791-92; Lacey, Tr. 6612; DX 296.) CDC already had been actively supplying data processing services to customers through its Cybernet computer network. The acquisition of SBC expanded CDC's service offerings: in 1974, CDC management termed the company "a world leader in data services". (DX 306, p. 2.) In 1973, CDC's revenues from EDP services were $143.6 million; by 1978, revenues had increased to $352.6 million. (DX 12302, p. 9; DX 12303, p. 2.)

In 1974, CDC reported that, "Data services have reached the stage of development where they provide the most cost-effective solution to an ever-widening range of problems and are the fastest growing segment of the computer industry." (DX 306, p. 2.) For 1976 CDC reported that, "The realization of the importance of data services as the most cost-effective way of meeting a wide range of computing needs has emerged rapidly as the industry has become more mature." (DX 2435, p. 8.) Norris testified that, at the time of his testimony in 1975, CDC was trying to convince users and potential users to employ its services offerings instead of using hardware of IBM and other companies. (Norris, Tr. 5820-21.)

For 1977, CDC reported that customers for its data services offerings included more than half of the Fortune 500 companies, the U.S. Government and its agencies, 4,500 smaller business clients, 80 of the nation's leading banks, more than 50 major insurance companies and 75 brokerage and investment banking firms. (DX 12302, p. 9.) In its 1977 Annual Report CDC summarized the evolution of the data services business from the offering of computer time to a complete service:

> "The data services business started by providing raw machine time to organizations having peak loads that they could not handle on their own equipment and to those having no equipment at all. In the intervening years, the business has moved increasingly toward providing a complete service rather than just computer time. Today, Control Data offers a wide range of application services that meet the specific requirements of selected industries or technical/scientific disciplines. Our growing capability in these selected areas provides an added value that helps differentiate us from competitors. We also gain an increased understanding of specialized business and technical problems for which our customers seek solutions. By applying this knowledge in new and improved application services we are able to enhance the quality of services we offer.

"A partial list of areas of specialization includes: petroleum exploration, nuclear reactor design and radiation safety monitoring, structural design and engineering, financial analysis, basic accounting and budgeting systems, sales statistics, planning models, credit union membership accounting and electric utility services." (DX 12302, p. 9; see also DX 11357.)

(iii) New Computer Lines. In the years after 1973 CDC introduced several new lines of computers. In mid-1975 CDC began to deliver the initial members of its Cyber 170 family of computers. According to CDC, the Cyber 170 "was partially funded and developed in Canada as an ongoing cooperative program with the Canadian Government." (DX 2435, p. 5.) At the time of the announcement of the Cyber 170, CDC advertised that the 170 was a "computer system that performs scientific, engineering, and business data processing . . . in timesharing, batch, remote batch and transaction modes." (DX 3103-A; see also DX 2308-A; DX 3101-A.)

In 1975 CDC introduced the Cyber 18 series of "small computers" primarily for "customers in petroleum, manufacturing, distribution and education. Many of these customers are smaller companies or divisions of larger organizations that are using Control Data equipment for the first time." (DX 2435, p. 5; see also DX 3112A.)

In the 1978-1979 period, CDC introduced additional new computer systems, including:

(a) In March 1977, CDC introduced two new models in the Cyber 170 series, the Cyber 171 and Cyber 176. Both of these models used a distributed network processing architecture.

(DX 14103.)

(b) In May 1977, CDC announced the OMEGA 480-I and 480-II systems, which were the company's first IBM plug-compatible processors. CDC claimed that OMEGA offered 10 to 100% performance improvements over comparable IBM systems at a 5 to 30% decrease in prices. (DX 2597, p. 2.) The OMEGA processors marketed by CDC were manufactured by IPL, a small Massachusetts corporation, partly owned by Cambridge Memories. (PX 5591, p. 3; see DX 2792.)

(c) In January 1978, CDC announced three new lower-priced models of its Cyber 175 Series and a lower-priced version of the Cyber 176. (DX 14400.)

(d) In June 1979, CDC announced a new IBM plug-compatible OMEGA processor, manufactured by IPL. CDC claimed that the new OMEGA was 1.3 times faster than the specifications for the IBM 4341. (DX 14104.)

(e) In April 1979, CDC introduced four computers, the Cyber 170 Series 700, which replaced five of the six models in its earlier Cyber 170 line. (DX 14105; DX 14106.)

c. <u>Digital Equipment Corporation (DEC).</u> From 1972 throug 1979, DEC's revenues continued to grow at a spectacular rate: from $188 million in fiscal 1972, to $422 million in fiscal 1974, to $1.8 billion in fiscal 1979, a compound annual growth rate of 38 percent. (DX 12323, pp. 28-29) For the first three quarters of fiscal 1980, DEC's revenues were $1.67 billion, up 30 percent over the first nine months of fiscal 1979. (DX 14107.)

DEC's impressive growth during this period was fueled by many equipment, programming and pricing announcements. For example:

(i) In June 1972, shortly after IBM's 3705 communications controller announcement (see p. 1043 above), IBM employees reported that DEC announced the PDP 11D23, a communications processor version of its successful PDP 11 line, which could attach directly to an IBM System/360 or System/370 channel and "perform functions similar to the IBM 3705. . . ." (DX 14125.)

(ii) In September 1972, DEC cut memory prices by 13% to 45% on the DECsystem 10 and its other computer lines. (DX 514, p. 12.) In its Annual Report, DEC attributed its ability to reduce prices to its new in-house peripheral manufacturing capabilities and to its acquisition of memory manufacturing and testing equipment from RCA, which permitted in-house testing of those products. (<u>Id.</u>)

(iii) Roughly two weeks after IBM's System/370 Model 125 announcement in October 1972, DEC announced "adaptation[s]" of its PDP 8 and PDP 11 processors under the marketing label DEC

Datasystem 300 and 500. (See pp. 989-91 above.)

In August 1973, a few months after IBM's System/370 Model 115 announcement (see p. 1052 above), DEC expanded its Datasystem 500 Series with several new processors, based on the PDP 11/40 or 11/45 CPU. (DX 14127.)

(iv) In January 1973, less than six months after IBM's announcement of virtual memory on its System/370 systems (see p. 1049 above), IBM employees reported that DEC announced virtual memory system hardware and software for its DECsystem 10 line. (DX 14126.)

By 1973, the DECsystem 10 was performing a "diverse" range of applications for time-sharing organizations, universities and commercial and industrial firms. (DX 510, p. 7.) Akers of IBM recalls that he lost a System/370 bid to the DECsystem 10 for a hotel reservation system to be installed at Ramada Inns in 1973. (Akers, Tr. 96730.) The DECsystem 10 replaced DEC's earlier PDP 10 systems. According to Hindle of DEC: "we really do not market anything today [1975] which we call PDP 10. We call everything we sell in that line DECsystem-10" regardless of what application it is performing. (Hindle, Tr. 7420.)

(v) By 1973, DEC's PDP 11/45, originally introduced in 1971 (Hindle, Tr. 7323), reached volume production. In 1973, DEC described the 11/45 as its "newest medium-scale computer" which had "proven popular with end-users as an alternative to large-scale computers." (DX 510, p. 6.) "Representative applications" of the PDP 11/40, 11/45, as well as the 11/70, included scientific and engineering applications, business data processing applications, real-time data collection and instructional computing applications, industrial control applications, commercial typesetting and data communications applications. (Hindle, Tr. 7440; PX 377A.)

The PDP 11/45 offered performance capabilities comparable to processors in IBM's System/370 line. For example:

(a) In 1974, it was reported that a user had linked 3330-type disk drives manufactured by ISS to ten multiprocessor clusters of three or four 11/45s each. As many as 24 IBM 370/135s would have been needed to perform the work being done by the 11/45s. (DX 612.)

(b) A 1974 IBM analysis estimated that the 11/40 and 11/45, then the largest members of DEC's PDP 11 series, had "functional capability varying from that of an IBM System/3 to an IBM System/370 Model 135, depending on the application for which it is being used". (DX 13285.)

(c) In 1975 Mr. Beard of RCA testified that with a fourth generation peripheral, such as an IBM 3330-type disk drive, a smaller computer like the PDP 11 can efficiently do the same kind of job that has previously been done on systems with larger computers performing commercial data processing applications. (Tr. 10050-51.) Beard added that in his opinion, there was an increasing trend in the direction of using smaller computers to perform tasks which were previously done on larger processing units used for commercial data processing applications. (Tr. 10051.)

(vi) In 1974, DEC announced two additional members of its DECsystem 10 family--the models 1080 and 1090. (DX 2861; DX 509A, p. 7.) At the time of their announcement, DEC stated that the 1080 and 1090 systems, which cost roughly between $600,000 and $1.5 million, were capable of performing "concurrent processing of timesharing, transaction processing, batch processing, remote batch, and realtime user requirements" and would be used in "business, education, science, industry and government". (DX 2861A, p. 1; DX 11439.)

A subsequent announcement in this series, the 1088--announced in early 1976--was "expected" by some within IBM "to compete with IBM System/370 Models 158 and 168". (DX 13289.)

(vii) In 1975, DEC introduced the PDP 11/70, at that time the high-end computer of DEC's PDP 11 series. (DX 509A, p. 7.) At the same time, DEC introduced a new operating system for the 11/70 called IAS, which, according to DEC, provided support for 16 interactive terminals and "simultaneous use of several programming languages. Time-sharing, batch and real-time programs can also proceed concurrently". (DX 509A, p. 7; see also DX 2602.) IBM analysts viewed the 11/70 as a processor "in the performance range of the IBM System/370 Models 135 and 145". (DX 13286.)

(viii) In 1976, shortly after IBM's System/370 Model 148 and 138 announcements, DEC introduced the first members of a new computer "family": the DECsystem 20. (DX 12321, pp. 3-5.) In 1977, DEC described those products, the 2040 and 2050, as "[d]esigned for multi-purpose use in commercial, scientific, and educational environments, the new system can support as many as 128 simultaneous users in an interactive, timesharing environment." (DX 3750, p. 10.) In early 1978, DEC announced two additional members of the DECsystem 20 line--the 2020 and 2060. (DX 12322, pp. 3, 7; DX 3524.) DEC advertised the DECsystem 2020 as "a full, general purpose mainframe computer system, with concurrent interactive time-sharing, multi-stream batch, and transaction-oriented processing . . . ." (DX 3524.) The 2020, as announced, supported up to 2 megabytes of main memory and 1.4 billion bytes of on-line disk storage; the 2060, as announced, had a main memory capacity of 5 million bytes and was supported by up to 56 disks. (DX 14393, pp. 3, 4; DX 3524.) In 1979, DEC expanded the main memory capacity of the DECsystem 2040 and 2060 to 12 megabytes--six times the maximum memory capacity of the IBM 370/148, and twice that of the 370/158. (DX 13297; DX 14110.)

(ix) In October 1977, within weeks of IBM's 3031 and 3032 processor announcement, DEC announced the VAX-11/780 as an upward-compatible expansion of the PDP-11 family. (DX 12322, pp. 5, 7.) The VAX-11/780 was introduced with a main memory capacity of 2 million bytes and offered the FORTRAN, COBOL and BASIC programming languages. (DX 14108.) In September 1978, DEC announced that it was increasing the main memory capacity of the VAX computer to 8 megabytes. (DX 14109.)

In marketing its products in the 1970s, DEC faced competition from a variety of companies. Speaking as of the mid-1970s, DEC's Vice-President and Group Manager, Mr. Hindle, identified DEC's "most significant" systems competitors as: Burroughs, Computer Automation, Control Data, Data General, General Automation, Hewlett-Packard, Honeywell, Interdata, IBM, Modular Computer Systems and Univac. (Tr. 7444.) He went on to identify DEC's plug-compatible competitors as including: Ampex, Beehive, Cambridge Memories, Centronics, Data Point, Diva, GE, Hazeltine, Keronix, Pertec, Plessey, Systems Industries, Teletype Corporation, Texas Instruments, Wangco and Xebec Systems. (Tr. 7444-45.)

DEC's product lines have achieved impressive success. By as early as 1973: "[O]ver 18,000 PDP-8s and 7,000 PDP-11s had been shipped, bringing the total of these shipments to over 25,000 machines". (DX 510, p. 5.) The uses of these DEC systems span a broad range of jobs:

> "We offer the user a wide range of computing tools. Our hardware includes a full range of peripheral devices, such as magnetic disk memories and tape drives, line printers, data terminals, communications options and market-customized options. We now offer a wide range of software operating systems or sets

of instructions that enable users to write their programs in symbology closely resembling the English language. This reduces the need for understanding the inner workings of a computer.

"The applications of minicomputers range from controlling simple machines making automobile parts to large and complex timesharing and industrial systems that do many things simultaneously.

"Our minicomputers will continue to be used to cut factory manufacturing costs, process goods, teach our children, improve the environment, perform scientific and engineering experiments, improve telephone service, aid the banking and insurance communities, and in general move and process data in many useful ways, some of which are yet unknown to us." (DX 510, p. 5; see also DX 12323, p. 2.)

Contributing to DEC's success was the continuing trend in the 1970s toward distributed data processing--a trend which "stimulated the breadth" of DEC's product offerings. (DX 12322, p. 8.) As DEC reported in 1979:

"This past year was marked by a further acceleration in the trend among computer users toward distributed processing, that is, the use of many decentralized computers dispersed throughout an organization and interconnected to permit communications among the individual 'local' computers or with a larger central computer.

"Digital's many years of experience with distributed processing have allowed us to press our advantage of having the industry's most comprehensive array of products to handle the wide variety of uses to which distributed processing techniques are being applied." (DX 12323, p. 3.)

d. Honeywell. Between 1973 and 1979, Honeywell's company-wide revenues grew from $2.4 billion to $4.2 billion (DX 165, p. 14; DX 12342, p. 3), and its Information Systems* revenue grew from $856 million in 1975 to $1.5 billion in 1979, a year which Honeywell described as one of "dramatic gains in sales and profits" for Information Systems. (DX 12342, pp. 9, 11.)

In the mid-1970s, Honeywell's management was aware of several trends in the EDP industry.

First, that the "computer industry is one of the few world industries where prices have gone down over the long term as value to the customer has increased. In large part the pace of technology makes this possible and helps keep us competitive." (DX 165, p. 19.)

Second, that the needs of computer customers were continuing to change:

> "Throughout the world, computer users are moving toward major overhauls in their computing facilities to make them more cost effective, to add new functions and to consolidate and streamline past practices. These changes inevitably affect the demand for Honeywell systems. We have seen the developing demand for large-scale, multi-function computer systems--such as the 6000 Series with advanced software--as users have consolidated their mid-range systems and added new functions. We also have seen the sharp growth in demand for very small systems in the Model 58 size class as new users have entered the market and as these systems are used as remote batch terminals to large central installations. This trend is likely to continue for many years." (DX 165, p. 19.)

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* "Information Systems includes products and services related to electronic data processing systems for business, governmental and scientific applications." (DX 12342, p. 39.)

Third, that in the "worldwide" market for computer products (Spangle, Tr. 5213, see also Tr. 5545-47; Binger, Tr. 4569-73; DX 195), Honeywell was facing an increasing number of competitors. As of their testimony in 1975, Binger and Spangle, Chairman of Honeywell and President of Honeywell Information Systems, respectively, identified a host of competitors for all or part of Honeywell's computer system line, including: Burroughs Corporation, Cambridge Memories, CII, Computer Machinery Corporation, Control Data Corporation, Data General Corporation, Data Products Corporation, Data 100 Corporation, Datapoint Corporation, Diablo Systems, Inc., Digital Equipment Corporation, Entrex, Inc., Fujitsu, General Electric, Hewlett-Packard Company, Hitachi, ICL, Incoterm Corp., Inforex, Incorporated, Infoton/Optical Scanning Corp., International Business Machines Corp., Management Assistance Inc./Basic Four/ Genesis, Memorex Corporation, Mohawk Data Sciences Corporation, NCR Corporation, Nixdorf, North American Philips Corp., Prime Computer Corp., Raytheon Company, Recognition Equipment Incorporated, Sanders Associates, Inc., Siemens, Singer Company, Sperry Rand Corp., Teletype Corp., Telex Corp., Varian Associates, and Xerox Corporation. (Binger, Tr. 4516-17, 4572-73, 4625; Spangle, Tr. 4938-41, 5179-81, 5545-47.)

One important aspect of Honeywell's business activities in the second half of the 1970s was a series of acquisitions and joint ventures. During this period, Honeywell: took over the domestic installed base of Xerox and agreed to service it; entered into a joint venture with CDC for the manufacture of peripheral equipment;

completed the purchase of GE's ownership interest in Honeywell Information Systems; effected the merger of CII and Honeywell-Bull in France; acquired Incoterm, a terminal manufacturer; acquired Synertek, a circuit, memory and microprocessor manufacturer; acquired Spectronics, a manufacturer of optical switches and fiber optics; and launched a joint venture with GE, combining part of Honeywell's time-sharing operations with those of GE.

(i) Xerox

Effective January 1, 1976, Honeywell assumed the responsibility of maintaining the domestic computer base of Xerox Corporation. Honeywell stated that "[t]his addition to our business is expected to increase Honeywell revenues and earnings and also provide an opportunity to add to our customer base" (DX 3355A, p. 13), and Honeywell reported that among the "major developments" of 1976 was "the profitable management of the Xerox computer base." (DX 12339, p. 5.)

(ii) CDC/Honeywell Joint Venture

Effective August 1, 1975 a joint venture, called Magnetic Peripherals Inc. (MPI) was formed between Honeywell and CDC, "to manufacture mass memory products". According to Honeywell the "major benefits" of MPI "will be to assure Honeywell users of the highest quality price/performance systems available, while offering significant technological and cost benefits to the participants through the integration of research and development capabilities and expanded manufacturing volumes."

(DX 3355A, p. 13.)

(iii) CII/Honeywell-Bull

As of June 30, 1976, Honeywell sold a portion of its 66 percent interest in Honeywell-Bull for $57.9 million to CII, and CII and Honeywell-Bull were merged. Honeywell owns a 47 percent interest in the merged company. (DX 12339, p. 25.) In 1976, Honeywell reported that:

> "The French Government has undertaken to grant significant support to CII-HB through March 1980, including annual purchases of computer systems and decreasing annual subsidies to cover transition costs of the merger." (Id.)

In 1979, Honeywell reported that Honeywell and CII/Honeywell Bull "develop and sell a common product line" and that the "combined pro forma revenue of Honeywell and CII/Honeywell Bull was $2.5 billion, compared to $1.5 billion for Honeywell Informations Systems alone. (DX 12342, p. 11.)

(iv) GE

In 1976 and 1977, Honeywell completed the purchase of GE's remaining interest in HIS. (See pp. 1089-90 above.)* In 1976, Honeywell issued 800,000 shares of stock to GE effecting a reduction of GE's interest in HIS to 11.7 percent. In 1977,

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* "In 1970, Honeywell and General Electric Company (GE) combined their computer operations principally by transferring them to Honeywell Information Systems Inc. (HIS), in which GE retained an 18.5% interest. Honeywell or GE could exercise an option to have Honeywell acquire GE's interest under the terms of the 1970 agreement." (DX 12340, p. 32.)

Honeywell acquired GE's remaining interest in HIS for 1.4 million shares of stock. (DX 12340, p. 32; DX 3338.)

(v) Incoterm

In 1978, Honeywell acquired Incoterm Corporation, "a manufacturer of intelligent computer terminals." (DX 12341, p. 4.) This acquisition "strengthened Honeywell's market position in terminals for banking, insurance, airline and manufacturing applications." (Id., p. 11.)

(vi) Synertek

Honeywell reported that Synertek "designs, manufactures and markets computer memories, microprocessors and metal-oxide-semiconductor/large-scale-integration (MOS/LSI) devices used in data processing, telecommunications, energy management, industrial controls and consumer products". Honeywell acquired Synertek "to strengthen the technology and product offerings in Honeywell's existing lines of business." (DX 12341, p. 21.) In 1979, Honeywell reported that, in 1980, Synertek will "substantially increase research and development in Very Large Scale Integration (VLSI) technology." (DX 12342, p. 23.)

(vii) Spectronics

Spectronics manufactures light-emitting and light-sensing devices, optical switches and fiber optics products for data transmission and automation control. According to Honeywell,

> "While Spectronics will concentrate on serving and expanding its present customer base, the new division is working with the Corporate Technology Center and the Solid State

> Electronics Center to develop new sensing, data handling and control technology for Honeywell products." (DX 12341, p. 21; see DX 12342, p. 14.)

(viii) GE Joint Venture

In 1978 Honeywell and General Electric formed a joint venture that "combine[s] Honeywell's timesharing marketing business in Europe and Australia with General Electric's worldwide timesharing operations." As a result, Honeywell acquired 16 percent of the "largest network timesharing business in the world." (DX 12341, p. 11.)

In the area of product introductions, as was the case with a number of IBM's other competitors, Honeywell devoted much attention during the 1970s to developing distributed processing alternatives. In its response to a 1977 Request for Proposal by the Battery Products Division of Union Carbide (see pp. 1412-15, 1418-19 below), Honeywell stated:

> "There was a time when state-of-the-art limitations forced users to place all their computer resources at a distant central site, and then to adjust their business operations to meet the restrictions imposed by such centralization.
>
> "That's changing today. Users now want to be able to distribute the power of the computer in the ways that best fit their needs, with as much--or as little--centralization as is required. They want distributed systems that will provide better response time, with on-site satellite computers and intelligent terminals to eliminate the delays often involved in 'round-trips' to a central system. They want distributed systems that will give local management closer, more direct control over local information processing operations, while still conforming to headquarters requirements and standards . . . distributed systems will improve availability, since a component malfunction may have less impact on system performance . . . distributed systems that will mean reduced communications needs, with far more transactions handled locally,

> closer to the end user . . . distributed systems that will offer almost unlimited flexibility to match the needs of individual organizational structures." (DX 3705, p. 127.)

In 1979 Honeywell observed that, "[c]ontinued worldwide growth is forecast for computers, especially minicomputers, terminals and distributed data processing systems." (DX 12342, p. 5; see DX 12341, p. 5.) Honeywell's "strategy in the computer business" is "to build strength in areas with the best growth potential--distributed processing, terminals and minicomputers--and to concentrate on specific growth markets where demand for these products offers major opportunities. Besides manufacturing, finance and the airlines, major targeted markets include distribution, government and other public organizations." (DX 12342, p. 13.)

Honeywell's product introductions reflected its interest in developing distributed data processing alternatives for computer customers.

In 1974, Honeywell introduced its new Series 60 computers, the "major goal" of which "was to create a single, advanced product offering from the variety of product lines resulting from the October 1970 merger of Honeywell and General Electric's computer interests." (PX 315, p. 13.) When the Series 60 was announced, Stephan F. Keating, president and chief executive officer of Honeywell was quoted as saying that, "Series 60 is based on the concept of distributed processing power . . . to provide increased throughput and superior cost-effectiveness." (DX 14198, p. 2.)

In early 1976, Honeywell announced the initial models of its Level 6 family of "minicomputers". According to Honeywell,

> "Simplicity, versatility and compactness are the key elements of the Level 6. Some models place Honeywell in an excellent position to serve the evolving distributed processing market, which links remote systems together so they can work independently and also share centralized computer resources." (DX 3355A, p. 14.)

In 1976, Honeywell listed among the "[m]ajor developments" in that year "Honeywell's formal entry into the field of distributed processing" and "the addition of more computers to our Series 60 and Level 6 minicomputer lines".* (DX 12339, p. 5.)

In 1977, Honeywell stated that "[d]istributed processing, which involves two or more computers altering or managing data in a cooperative manner, is considered an area of substantial future

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* Honeywell has stated that "[a]bove all" the Level 6 is a "minicomputer system. That is, it comprises modular hardware and software components that you can mix and match in virtually any combination to help meet your processing requirements for both commercial and scientific applications." (DX 12955, p. 2.) Level 6 is expandable to 2 million bytes of main memory and can support up to 1 billion bytes of on-line disk storage, COBOL, FORTRAN, and operating systems that permit "simultaneous execution of any number of user programs in software dispatched real time, time sharing, batch processing, and transaction driven modes." The Level 6 supports Honeywell's IDS II or Cincom's TOTAL data base management systems. (Id., pp. 10, 12.)

In 1975 Spangle described Honeywell's "minicomputer" business as

> "a business consisting of the development, manufacture and marketing of small general computer systems which are used in a variety of fields of endeavor, one of which is business data processing." (Tr. 4915-16.)

Spangle defined a minicomputer as "a small general purpose computer, and small is a relative term, smaller than other computers." (Tr. 4916.)

growth for the industry. Honeywell's significant expansion in minicomputers, continued strength in large systems and broadening of its line of intelligent terminals give it a strong position in distributed systems." (DX 12340, p. 4.) With respect to the Level 6, Honeywell stated in 1977 that it had "achieved solid success" and that "[i]ts broad range of applications include use as a free standing computer and as an integral part of distributed systems and data networks. The Level 6 also finds wide use in control systems produced by other Honeywell divisions."* (DX 12340, pp. 4, 6.)

During the past two years Honeywell has announced members of its Distributed Processing Series (DPS) computers. These announcements, as well as the introduction of other computers, were specifically aimed at IBM's computers ranging from the System/3 to the 3000 Series:

(i) In 1978, Honeywell introduced its Level/66 DPS, which reportedly "roughly covers" the IBM 3031, 3032 and 3033 in performance. (DX 14111.)

(ii) In early 1978, Honeywell "reconfigured" its Level 64

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* Those other divisions include: Environmental Systems and Controls--"products and services related to building automation, fire and security protection, and energy management in residential and commercial markets", Industrial Systems and Controls--"control devices, analog and microprocessor based instruments and computer based systems for data acquisition, monitoring and control of industrial and electric utility processes and components"; and Aerospace and Defense--"the design, development and production of guidance systems and controls for military and commercial aircraft, space vehicles, missiles, naval vessels and military vehicles." (DX 12342, p. 39.)

"medium-scale computers" and "substitut[ed] a single expandable model for the line's previous five submodels". These computers were reportedly designed to provide IBM System/3 users with an "upward migration path" and were directed at the "low end" of IBM's System/370, the Models 115 through 138. (DX 14252.)

(iii) In 1979, Honeywell introduced various additional models of its Level 66 and Level 64 systems that, according to Honeywell, are price/performance competitive with IBM's 4341 and 4331 processors. (DX 14128.)

(iv) In January 1980 it was reported that Honeywell replaced two models of its Level 64/DPS with a new model made in France by CII/Honeywell-Bull, aimed at the IBM 4331 and System/38. The new models also feature a software product to aid conversion of IBM System/3 users. (DX 14112.)

e. <u>Hewlett-Packard.</u> Hewlett-Packard did not ship its first computers until 1967. Beginning with computers "designed to complement the company's measuring instruments", Hewlett-Packard has since introduced a variety of computer products intended "to serve a broad spectrum of customer needs". (DX 12334, p. 21.) The company today describes its HP 3000 family of products as a "line of general purpose computers." (DX 11610.)

Hewlett-Packard has achieved impressive success in its EDP business, which has become an increasingly significant portion of the company's total operations. By 1972, domestic EDP revenues accounted for nearly 15 percent of total corporate revenues--$68 million out of a total of nearly $480 million. (DX 14078, p. 3; DX 8224, p. 540.) By 1975, worldwide EDP revenues were up to about $390 million (DX 3749, p. 5), and in 1979 Hewlett-Packard's EDP revenues were over $1 billion, almost 50 percent of total corporate revenues. (DX 13945.)*

In 1978, just over 10 years after its first computer shipment, Withington ranked Hewlett-Packard among the "ten largest computer systems manufacturers" in the United States. (Tr. 58669-70.)

Early in 1972, Hewlett-Packard announced the HP 3000 computer system line, which was, according to the company's

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* In 1979, Hewlett-Packard was ranked 150th in the Fortune 500 list of the nation's largest industrial corporations.

management, its "first venture into the medium-sized computer field". (DX 6926, p. 20.)* The equipment and operating system software were designed to handle simultaneously "time-sharing, real-time, multi-programmed batch, and on-line terminal operations--each in more than one computer language". (Id.)

In the early stages of HP 3000 shipments Hewlett-Packard encountered difficulties with its performance. In May 1973, Terry, Vice-President and General Manager of Hewlett-Packard's Data Products Group, testified:

> "We started shipping these machines in February [1973] and we have been somewhat disappointed with the performance of the first version of the software operating system. It is not living up to our goals in terms of what it does and its reliability and we are hard at work improving it." (DX 4113: Terry, Tr. (Telex) 3330; DX 14078, p. 2.)

Terry further noted that, in his experience at Hewlett-Packard, "it is not unusual that the first version of any significant contribution doesn't quite do all the wonderful things you want it to do ultimately. It takes time to perfect and enhance it and we continue to expend a great deal of engineering on all of our products." (DX 4113: Terry, Tr. (Telex) 3332.)

Between 1976 and 1979, Hewlett-Packard enhanced its 3000 series with the introduction of the 3000 Series II in 1976, the 3000 Series III, the Series 33 in 1978 and the 3000 Series 30 in

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* Prior to that time, Hewlett-Packard had been manufacturing its HP 2000 series, smaller "general purpose" computer systems. (See DX 4113: Terry, Tr. (Telex) 3293-94, 3303.)

1979. (DX 11700.) The newer 3000 Series computers offer main memory capacity up to 2 million bytes, as well as communications and networking capability permitting interaction of remotely located Hewlett-Packard processors and terminals. (DX 11609; DX 12938, p. 19; DX 11589; DX 11595.) In addition, the 3000 Series is provided with operating system software that "can simultaneously handle traditional batch processing [and] interactive processing for up to 63 terminals" and support a variety of languages such as COBOL, FORTRAN and BASIC as well as Hewlett-Packard's IMAGE data base management system. (DX 12938, p. 19; DX 11609; DX 11589.)

Communications and networking capability was perceived by Hewlett-Packard as putting it in "an ideal position to benefit from [the] trend" in the latter 1970s toward distributed processing. Hewlett-Packard reported in 1978:

> "Large mainframe computers, operated to their full capabilities, become inaccessible and less well suited for many of today's applications. There is growing interest in distributing some of the processing load away from these central mainframes to smaller computers at key locations throughout an organization." (DX 12335, p. 6)

The company further reported that "[u]ser interaction with a computer is very often accomplished through data terminals" and "[f]or that reason . . . HP terminals are a key element in attracting customers to our computer systems". (Id., p. 8.)

In addition to its processors and terminals, Hewlett-Packard offers a full range of peripheral products, largely manufactured in-house, for use with its HP 3000 series.* According to the company's management:

"HP's broad line of peripheral products for use with computers is designed and manufactured in-house, and include disc memories, magnetic tape units, high speed plotters, and card readers. Having this range of peripheral equipment gives the company an advantage when competing for data systems business." (DX 6926, p. 20.)

On this same subject, Mr. Terry testified:

"Q Do you believe that the availability of better and faster input/output equipment is important to you in being able to market the 3000 series?

"A It is extremely important. A very high percentage of the value of the computer system is represented in the peripherals and, to the extent you can make a contribution in these peripherals, it has a great deal to do with the total contribution of the system.

"Q Has it been your experience that customers, in choosing between competing systems, give great weight to the quality and price/performance of peripheral equipment attached to those systems in making their decision?

"A Yes, I believe they do." (DX 4113: Terry, Tr. (Telex) 3304.)

Hewlett-Packard has described customer uses of the HP 3000-II as including: customer order, production and warehousing applications for a textile manufacturer; customer account and advertising accounting for a cable TV and radio company; accounting, personnel and management work for a retail store chain; and accounting, management and engineering applications for a municipal water utility. (DX 12935, pp. 9-12.)

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* In the early 1970s, Hewlett-Packard acquired 2314-type disk drives from ISS. (DX 4113: Terry, Tr. (Telex) 3311-12.)

In the 1970s, the HP 3000 was marketed for a wide range of applications, in competition with IBM and other EDP suppliers. For example:

(i) As described in detail below (see pp. 1416-18), Hewlett-Packard equipment was among the alternatives bid in response to Union Carbide's major request for proposal for production scheduling applications. Comserv, one of six bidders, proposed HP 3000 equipment, in a distributed data processing configuration. (DX 3704, pp. 2, 40-43.) IBM bid System/3, System/34 and System/370 equipment; Univac, the winner, bid a "clustered" network of 90/30 computer systems equipment. (See pp. 1422-23, 1426-28 below.)

(ii) In 1978 it was reported within IBM that Hughes Aircraft had installed an HP 3000 computer for inventory and procurement status applications, which was described as "a standalone application with periodic updates from a host data base". Hughes considered implementing this application utilizing IBM's IMS data base management system on IBM 370 processors, but selected HP 3000 because it was a "simple solution". (DX 9409, pp. 87, 89.)

(iii) It was similarly reported that in 1977 Union Camp had installed HP 3000s for on-line interactive order entry and production scheduling as well as programming development. (Id., p. 134.) IBM had unsuccessfully bid a 370/158 MP upgrade to an existing 370/158 at Union Camp. (PX 6467, Vol. IV, April, p. 13.)

(iv) It was also reported within IBM that in 1977 General Mills began installing a 13-system HP 3000 network to provide inventory management control for 26 warehouses associated with six food plants. One of the HP 3000s was to act as the network controller for the other 12. (DX 9409, p. 130.)

(v) In 1977 Hewlett-Packard reported that an HP 3000 Series II had replaced "a batch computer" at Schlegel Corporation to control all material requirements planning and for order entry and major accounting operations. (DX 11588.)

(vi) In 1979, according to Hewlett-Packard, the Spalding Company was using three HP 3000 Series II computers linked together in a computer network, performing order processing applications.* (DX 11606.)

(vii) In 1979 it was reported within IBM that Hewlett-Packard computers had been "active" in competitive situations against IBM's 4300 processors (DX 9407; DX 9408) and also that IBM had successfully bid 4341, 4331 and 370-138 computers against some Hewlett-Packard 3000 Series equipment proposals. (PX 6467, Vol. VI, April, p. 16; September, p. 14.)

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* In 1978 it was reported that Spalding had previously employed centralized batch methods on a Univac 1050 and Honeywell 2040, which were to be replaced by the three HP 3000 II's. According to this report the three HP computers at Spalding were to include 1.25 million bytes of main memory, 1.3 billion bytes of on-line disk storage and was planned to be connected with 152 CRTs, graphics terminals, printers and plotters in eight warehouses and seven sales locations around the U.S. (DX 14378.)

f. Memorex. Beginning in 1974, Memorex began a turn-around from the problems and poor financial performance it had experienced in the first years of the 1970s. In 1974, Memorex had revenues of $217,627,000, up from the prior year's $176,923,000. (DX 1273, p. 1.) Memorex' management termed the next year, 1975, "a time of restoration: restoration of positive attitudes, restoration of profitability, and restoration of positive net worth". (DX 1274, p. 2.) Memorex increased its revenues to $263,994,000. (DX 1274, p. 2.) By 1977, revenues were up to $450 million. (PX 5592, p. 3.) In that year, Memorex appeared on Fortune's list of the 500 largest industrial corporations in the United States and the company's common stock was relisted on the New York Stock Exchange. (Id., p. 4.) By 1979, with revenues reported to be nearly three-quarters of a billion dollars (DX 13945, p. 15), Memorex was ranked as the 346th largest industrial firm in the United States by Fortune. (DX 13946, p. 288.)

In this period, Memorex offered new disk, tape, memory and communications products. The announcements through 1975 included:

(i) The 3673 disk controller, which permitted Memorex disk drives to attach to IBM's Integrated Storage Controller, an optional, integrated disk control feature on certain System/370 processors. (DX 1273, p. 6; DX 11770; see p. 1016 above.)

(ii) The 6000 Series add-on memory, which Memorex described as expanding internal memory capacity of IBM's System/360 and 370 processors "at substantial cost savings over IBM equivalents". (DX 1273, p. 7; see DX 11774; DX 11779.)

(iii) The 1380 programmable communications controller, a plug-compatible replacement for IBM 3705 controllers. (DX 1274, p. 6.; see DX 11774; DX 11775.)

(iv) The 1377 display terminal, a plug-compatible replacement for IBM terminals used with 360 and 370 processors. (DX 1274, p. 7; see DX 11774; DX 11775.)

Memorex continued to expand its product line in subsequent years. In 1976, Memorex announced the 3640, an IBM 3340-type disk drive manufactured by Nippon Peripherals, Ltd. and marketed by Memorex. (Navas, Tr. 39713, 41250-59; G. Brown, Tr. 52721; DX 1635, pp. 6-7; DX 2351.) The 3640 reportedly "utiliz[ed] advanced Winchester technology". (DX 2351.)

In the same year, Memorex introduced the 3650 disk drive, which was announced as incorporating the latest "'Winchester' [t]echnology" and offering "full functional compatibility with the IBM 3350", which had been announced in 1975. (DX 1635, p. 7; DX 11774; DX 11775; see pp. 1296-97 below.) In 1977, Memorex reported strong demand for its 3650 and 3640 products. (PX 5592, p. 8.)

Also in 1976, Memorex announced a new memory system, the 6268, as well as a new tape system, which was said to utilize "the latest 6250 BPI technology"--the same storage density available on

IBM's highest performance tape drives. (DX 1635, p. 8; see pp. 1054-55 above.)

In 1978, Memorex announced its 3770 Disk Cache which consisted of a microprocessor and semiconductor memory device. The 3770 was intended for use with the Memorex 3670 and 3675 disk drives to permit faster access time and increased system throughput. (DX 13397, p. 8; DX 13681, p. 18; see DX 11778.) That same year, Memorex opened a new flexible, or "floppy", disk drive manufacturing plant and expanded other production facilities. (DX 13397, p. 13.)

In 1979, Memorex introduced the 3652 disk subsystem, a double density 3350-type disk drive, featuring 635 million bytes of storage, and a low capacity drive with an 11.7 million byte capacity, for use with "word processing and minicomputer" equipment. (DX 13681, pp. 4, 19; see also DX 11786.)

In addition to product developments, Memorex acquired Business Systems Technology (BST), a supplier of storage and communications products. (PX 5592, p. 13.) Among other products, BST offered plug-compatible peripheral products for attachment to IBM System/3 processors. (PX 6553; PX 6554; see DX 13133; DX 13134.) In 1978, Memorex entered into a joint venture with a Japanese industrial concern, Teijin, to produce Memorex flexible media in Japan. (DX 13397, p. 3; DX 13681, p. 4.) Also in 1978, Memorex acquired Telex Europe, which increased Memorex's customer base and increased the company's marketing strength in Europe. (DX 13397, pp. 3, 23-24.)

g. NCR. NCR's corporate revenues grew from $1.8 billion in 1973 to slightly over $3 billion in 1979. (DX 339, p. 30; DX 14088, p. 1.) Its "computer systems" revenues increased from $38 million in 1974 to $838 million in 1979, and revenues from retail, financial and general purpose terminals and systems increased from $295 million in 1974 to $959 million in 1979. (DX 368, p. 19; DX 14088, p. 25.) NCR achieved this growth largely through internally generated funds. (DX 14088, p. 3.)

In the middle of the decade, NCR's management was aware of the active and expanding nature of competition in the computer industry.

(i) Oelman, NCR's Chairman until 1973 (Tr. 6117), testified:

> "I think the . . . competitive situation is changing very rapidly in the electronic computer or electronic data processing business. The entire advent, for example, of the minicomputer with its host of companies getting into the business, provided a completely new dimension of competition for the EDP company." (Tr. 6129-30.)

(ii) Hangen, NCR Senior Vice President (Tr. 6239), testified that in the 1960s NCR faced competition from IBM, RCA, GE, Honeywell, Burroughs and CDC. (Tr. 6338.) He went on to state that as of the time of his testimony in 1975, NCR competed against numerous companies in the U.S. in the manufacture and marketing of "computers, computer systems or peripherals", including: Advanced Memory Systems (AMS), Amdahl, Ampex Corporation, Burroughs, CalComp, Centronics Data Computer Corporation, CDC, Data General, Data Products Corporation, Decision Data Computer Corporation, Diablo Systems, DEC, Four Phase Systems, General Computer Systems, Hewlett-Packard, Honeywell, IBM, MAI/Basic Four, Memorex, Nixdorf, Pertec Corporation, Sperry Rand, STC, Telex and Varian. (Tr. 6399-6411.)

(iii) Oelman identified a group of companies listed in an internal NCR memorandum as among those companies NCR faced as competitors in the areas of "mainframe[s]", "peripheral[s]", "terminal[s]" and "minicomputer[s]" in the 1970s. (Tr. 6188; DX 363.) The competitors included: Burroughs, CDC, Data General, Datapoint, DEC, Four Phase, General Automation, Hewlett-Packard, Honeywell, IBM, Litton/Sweda, MAI/Basic Four, Nixdorf, Olivetti, Philips, Qantel, Sperry Rand, Varian, Wang and Xerox. (Tr. 6194-95; DX 363.)

Oelman testified that, in addition to the list of competitors, "[t]he industry is such a dynamic one . . . I am sure every day there are new and additional competitors in . . . electronics", "[a]cross the board". (Tr. 6195-96; 6201.)

(iv) In a 1974 Domestic Marketing Five Year Strategy document, NCR identified a number of competitors which had expanded their product offerings into new areas during the 1970s. The companies included: IBM, Univac, Singer, Burroughs, AT&T, Texas Instruments, RCA, Focus 4, Basic 4, DEC, General Automation, Hewlett-Packard, Interdata and Varian. (Hangen, Tr. 10438-40, 10445-46; DX 741-B, p. 1.) The strategy document also took account of increased foreign and third-party leasing company competition (DX 741-B, p. 2), and stated that a significant competitive force in the future would be new entrants into the EDP industry. (DX 741-B, pp. 2-3.) The study further noted that technology was advancing at a pace faster than companies could utilize it; as a result, the technology improvements fueled the "prolipheration [sic] of competition." (Id., p. 5.)

By the end of 1975--and in the face of ever-increasing competitive activity--NCR's Century Series, announced in 1968, had effectively reached the end of its product life. In 1976, NCR introduced the first models of a new computer line, the "Criterion", which NCR characterized as "an advanced general-purpose computer which provides solution-oriented data processing for industrial, financial, retail, commercial, educational and governmental organizations". (DX 2760, p. 9.)

The Criterion line offered "new standards of performance and versatility" compared to the Century line. (DX 2760, p. 9.) In January 1976, Hangen testified that NCR had to offer products with improved price/performance or it would not be able to keep abreast of competitors that were "constantly striving to come up with . . . improved products with improved price/performance." (Tr. 10423-24.) He testified that improvements in price/performance of a product are important since users base their procurement decisions on this factor. (Tr. 10419.)

Hangen also testified that, during the 1970s, NCR was spending an ever increasing amount of money on research and development. (Tr. 10422-23.) He stated that because computer technology had been changing, and was continuing to change, at a very rapid pace, successful research and development was "essential" to NCR's ability to be competitive in the EDP industry. (Tr. 10422-24.)

Between 1976 and 1979, NCR announced a number of Criterion processors--from the low-end Criterion 8100 to the "very large-scale" Criterion 8600. (DX 14087, p. 1; DX 14088, p. 14.)

In 1977, "NCR expanded its 8000 computer series from three models to 15 . . . giving the company a new line of data processing systems". The largest Criterion processor at that time was the 8590, which "provides up to six million bytes of main memory". (DX 14086, p. 5; DX 12842, p. 3.)

In 1978, NCR announced the Criterion 8600, which was reported to have a capacity of up to 16 million bytes of main memory and 15 percent greater performance than the IBM 3033 processor, announced in March 1977. (DX 14087, pp. 1, 14, 15; DX 14265.) NCR stated that these new, "very large processors", along with its operating systems and other software, gave the company "a greater opportunity than ever before to develop new customers among medium-sized and large manufacturers". (DX 14087, p. 4.)

In 1976, NCR announced the NCR 499 computer series, replacing the successful NCR 399. (Hangen, Tr. 10716.) An NCR pricing plan for the 499, created approximately 10 months before announcement, listed a sampling of competitors to the 499; they included: Burroughs, Nixdorf, Philips, Sweda-Litton, Datapoint, DEC, Wang, Basic-Four, IBM, Lockheed, Qantel and Singer. (Hangen, Tr. 10715-17; DX 809, pp. 6-10.) NCR's 499 product plan analysis commented on the degree of competitive activity for small general purpose computer systems:

> "The major characteristic of today's competitive marketplace is the increasing velocity of change. A few major producers of Accounting Systems such as NCR, Burroughs, IBM, and Litton once produced most of the offerings to the marketplace. This is no longer true. Data Pro reports that 40 vendors offer over 150 small business systems models. An increasing number of new vendors are offering small data processing systems to the entry level commercial market. Just a few years ago the Singers, Basic/Fours, Qantels, and the Datapoints were unheard of. Major producers of scientific minicomputers and calculators, such as DEC, Olivetti and Wang have recently introduced small business processing oriented versions. Major overseas producers such as Nixdorf and Philips have penetrated the U.S. market.
>
> "This multiplication of competitors has produced two major results in the marketplace. First, the acceleration of technology and its introduction into the marketplace is producing shorter market lives for most small business systems. Secondly, this multiplication has promoted decreasing price stability as the various vendors react to these new introductions in the marketplace. A good example of these forces at work is the change in the marketplace since IBM introduced the System 32. Burroughs reconfigured and repriced their B700 series, DEC introduced their 310 Diskette Based Business System, and Qantel announced new Models 850 and 900 (6M Bytes Disk Systems) at purchase prices under $25,000." (DX 809, p. 4.)

With respect to communications and distributed processing, in 1975 NCR noted that a "strong trend toward decentralized data processing networks, including various types of data terminals, is rapidly changing both the shape and substance of the industry." (DX 3354, p. 9.) In 1976, NCR reported that communications is "a powerful third force in electronic data processing, linking terminals and other data entry devices with central processors". (DX 2760, p. 12.) According to NCR, the increasing utilization of distributed processing and technological advances in computers were opening up new areas of opportunity for computer manufacturers:

> "Advances in technology and design continue to enhance dramatically the performance of computer systems. As a result, smaller systems to an increasing extent are replacing the large central processors which historically have paced the growth of the data processing industry.
>
> "These advances have created major new markets for computer manufacturers. One of these markets is comprised of large companies which are installing distributed processing systems. In systems of this type, many of the functions of a giant central computer are performed by a network of smaller systems which are at the same time responsive to local processing needs. Such systems complete much of the work at the local level, forwarding only selected data to the user's headquarters computer.
>
> "A second rapidly growing market created by today's more powerful but less costly systems consists of small to medium-sized organizations which formerly were largely outside the realm of electronic data processing. Now such organizations can install versatile, high-performance equipment at an affordable cost." (DX 2760, p. 14.)

In addition, advances in microelectronics have "made possible the development of 'intelligent' data terminals with more processing power and memory than the large computer of the 1950's." (DX 14086, p. 16.) NCR has taken advantage of these advances in the development of its terminals:

"Miniaturized circuits and memories are being used throughout NCR's terminal product line in order to move 'intelligence' into areas where it is needed. Today, it is not unusual to find small freestanding terminals with up to 64,000 bytes of memory and the same processing power as relatively large computer mainframes of only a few years ago." (DX 14087, p. 6.)

In 1979, NCR acquired Comten, a successful manufacturer of IBM-compatible, programmable communications controllers. Comten was called by one industry observer "the leading manufacturer of IBM and PCM front end processors". (DX 14088, pp. 2, 5, 32; DX 12259, p 2.) Comten had grown from revenues of $9 million in 1973 to over $50 million in 1978. (DX 14072, p. 1; DX 12259, p. 2.)

NCR management stated that the Comten acquisition "enhanced" NCR's communications capabilities, believed to be significant because "[t]he shift of computing power away from centers of concentration and close to individual users will further expand the role of communications in information processing systems" (DX 14088, p. 5.) That view was echoed by the financial community. For example, one source commented on NCR's acquisition by stating that it will

"allow NCR to compete more effectively in the heavily data communications, network-oriented environment foreseen in the 1980's. COMTEN will provide the interfaces to IBM's mainframe equipment which will allow NCR to sell its terminal-based systems to IBM's data processing customers, creating additional mixed environments of IBM and NCR systems." (DX 12259, p. 2.)

In 1979, NCR summarized the range of its product offerings:

"The NCR total systems concept encompasses one of the broadest hardware and software product lines in the industry. NCR computers range from small business systems to the most powerful general-purpose processors, and are supported by a complete spectrum of terminals, peripherals, data communications networks, and an extensive library of software products. Supplemental services and products include field engineering, data centers, systems services, educational centers, and a comprehensive line of media." (DX 14088, p. B.)

h. <u>Sperry Rand.</u> Sperry's computer operations grew throughout the decade of the 1970s. In its most recent report to its shareholders, Sperry stated that "Computer Systems and Equipment' revenues had grown from $635 million in fiscal 1970 (March 31) to $2.319 billion in fiscal 1980. (DX 14093, p. B.) That growth, more than 350 percent, was substantially greater in percentage than the growth in Sperry's total corporate revenues during the decade: from $1.8 billion to $4.8 billion. (<u>Id.</u>) Moreover, the Univac division's growth in the decade 1965 through 1974 parallels its performance between 1970 and 1980. During the 1965-74 period, Sperry Rand as a whole grew at a compound annual rate of 11.7 percent while the Univac division grew at a 16 percent compound rate and almost quadrupled its revenues. (DX 64, p. 32; see also DX 65, p. 2; McDonald, Tr. 3856-57; 3878-79.)

Univac achieved its growth during the 1970s despite the fact that, as it noted in Sperry's 1977 Annual Report, competition had become "more intense both in the United States, with new vendors entering the industry, and overseas, where greater government intervention in favor of indigenous companies was clearly apparent." (DX 12382, p. 21.) And Sperry expects that its computer operations will continue to prosper during the 1980s. In its 1980 Annual Report, Sperry's management reported that it expects the value of worldwide shipments of general purpose computers to grow 60 percent by 1985 and that "Sperry Univac expects to continue to grow more rapidly than the industry as a whole. The division's objective is to increase revenues at a rate of 15% per year and to increase profits at an even higher rate." (DX 14093, pp. 4-5, 12.) Management noted that in 1974 "there were 162,000 computers in operation in the U.S. By 1983, the forecast is for nearly 3.7 million." (Id., p. 4.)

The continued success of Sperry's computer operations during the mid- and latter 1970s was fueled by two factors: the introduction of a variety of new products and several acquisitions, in addition to the company's earlier RCA and ISS transactions. (See pp. 1001-02 above.)

(i) Product Actions. In 1973, a major portion of Univac's product line was its 1100 Series of computers, which, with enhancements, continued to win business well into the decade. Sperry reported in 1976 that, during the previous year, new orders were received for its "large-scale computers" from state and local governments, airlines, educational institutions, oil companies and utilities, banking institutions, manufacturing companies and communication companies. (DX 12382, p. 21.)

Between 1973 and 1980, Univac announced a number of new models to the 1100 Series:

(a) In November 1976 Univac introduced the 1100/10 in the 1100 family. (DX 12381, p. 15.) The 1100/10 was described as a "medium-scale" computer which offered capabilities usually "available only in large-scale systems such as the 1100/20 and 1100/40." (Id.) The 1100/20 was reportedly capable of supporting about 2 million bytes of main memory and the 1100/40 up to about 4 million bytes. (DX 14122.)

(b) During fiscal 1977 Univac announced the 1100/80, which was reported to have a main memory capacity of 16 millio[n] bytes, and on-line disk capacity of about 6 billion bytes. (DX 12382, pp. 6, 21; DX 13786.) The 1100/80 was the most powerful member of the 1100 line. (DX 13786, pp. 4, 5.)

(c) In June 1979 Univac announced the 1100/60, which was reported to be Univac's response to IBM's 4341 processor, announced by IBM in January, 1979. (DX 12384, p. 5; DX 13822; see p. 1335 below.) The 1100/60 was said to offer performance ranging from below the IBM 4341 up to the IBM 3032 processor, announced in 1977. (DX 14420.) According to Sperry the 1100/60 "combines LSI (large-scale integration) circuitry with a unique framework of multiple microprocessors" (DX 14093, p. 9.). Sperry reported that "[t]his system brings large scale multiple processor architecture out of the laboratories and into the market". (DX 12384, p. 5.)

For fiscal year 1980, Sperry reported that bookings for the 1100 Series alone exceeded $1 billion. (DX 14093, p. 9.)

Another major portion of Univac's product line in the 1970s was its 90 Series, the first members of which, the 90/60 and 90/70--follow-on products to the RCA Spectra Series--were announced in 1973. (DX 64, p. 4.) Univac subsequently enhanced the 90 Serie[s] For example:

(a) In January 1975 Univac started deliveries of the 90/30 "small-to-medium-class computer". (DX 62, p. 10.) The following year, the company reported that nearly 60 percent of its more than 1,000 orders for the 90/30 "were from new customers, who had formerly used competitive products or who did not previously have a computer doing the work assigned to the 90/30". (DX 12381, p. 15.)

(b) In 1976 Withington reported that Univac had responded to IBM's announcement of the System/370 Model 138 and 148 processors (see pp. 1307-08 below) by increasing the 90/60's main memory and internal performance and by reducing prices of other Series 90 equipment in August of that year. (DX 2681, p. 4.) As a result of those and other price/performance improvements to the Series 90, Univac reported that the 90/60 was placed "in the gap between the recently announced IBM models 370/138 and 370/148", and the 90/70 and 90/80 "now bracket the IBM model 370/148 in performance and price and offer the prospective user considering acquisition of a 370/148 two very attractive alternatives." (DX 14129, pp. 3-4.)

At the same time that it was adding products to its 1100 and 90 computer lines, Univac also was pursuing its "distributed communications architecture" through the introduction, in 1976, of its Universal Terminal Systems (UTS) line. (DX 12381, p. 15; DX 14093, p. 11.) Sperry stated:

"These systems represent Sperry Univac's newest generation of distributed processing products, which started with the 9200 and 9300 remote processors and extend through to the 1100 series systems introduced in the late 1960's. Using latest microprocessor technology, high density diskette or disk cartridge for local data storage, and industry compatible programming languages, the UTS family brings computer power to a much broader base of users at much lower cost." (DX 12381, p. 15.)

In addition to being usable with Univac's computer equipment, the UTS line can be used with other manufacturers' equipment, including IBM, through emulating IBM software protocols. (DX 13021, p. 9; see Withington, Tr. 57066-68.)

(ii) Acquisitions. As noted earlier, in the early 1970s, Sperry acquired ISS and RCA's computer business. (See pp. 1001-02 above.) The ISS acquisition provided Sperry with substantial in-house disk capability and ISS continued to develop and manufacture disks for both Univac systems and as plug-compatible replacements for disks on IBM systems. (See p. 1296 below.) The RCA transaction made a significant contribution to Sperry's growth in later years: By the end of 1974, Sperry had realized $61 million from bookings of Univac computers to RCA equipment users, $27 million from Univac disk and tape products marketed to RCA users and cumulative revenues--in sales, rentals and maintenance--of $370 million from RCA's installed equipment. (DX 68, pp. 11-12; McDonald, Tr. 3900-03, 3908-09.)

During fiscal 1976 Sperry acquired the disk manufacturing facility of Caelus Memories, Inc. In 1976 Sperry stated that "[w]ith this new internal source of supply, Sperry Univac is less dependent on outside vendors for volume supplies of quality disks". (DX 12381, pp. 2, 12.)

The following year, Sperry acquired Varian Data Systems, a manufacturer of computer systems. This acquisition resulted in an expansion of Univac's product coverage. In 1978, Sperry introduced an extension to Varian's existing computer line, the V77 Series. The new product, called the V77-800, was described by Sperry as "a general purpose microprogrammable minicomputer providing superior performance in scientific, commercial and data communications applications." (DX 13022, p. 1.) The V77-800 "minicomputer"--or "miniframe", as it was called by Univac (DX 11972)--supports up to 2 million bytes of memory, languages such as COBOL, FORTRAN, RPG II, and the TOTAL data base management system. (DX 13022, pp. 2, 3, 4; DX 11972.)

Sperry's V77 Series also supports its "PRONTO Transaction Processing System", which permits the user to install a V77 computer between an IBM 3270 remote terminal subsystem and an IBM 370 computer. This configuration allows local applications to run "with minimum involvement on the part of the host 370." (DX 13020.) According to Sperry, "PRONTO cuts down your host 370 transaction workload. . . . By off-loading the central computer, you cut processing costs and put a lid on escalating network charges. . . . [N]ew applications designed to meet local branch or division requirements and which formerly would have had to be installed on the central processor can now be put in the hands of a local computer, cutting expensive host transactions." (Id.)

i. <u>Storage Technology.</u> STC, which was not formed until 1969 and reported no revenues until 1971, had grown by 1975 to revenues of nearly $100 million. By 1979, its revenues had soared to $479 million, and it was ranked 457 in Fortune's list of the 500 largest industrial corporations in the United States. (PX 4699, p. 4; DX 12608, p. 43; DX 13946.)

During the 1970s, STC became the industry's leading independent tape supplier. In addition, STC announced a number of advanced disk products, including:

(i) In 1976, STC responded to IBM's 3350 ("Madrid") disk announcement of 1975 by introducing a plug-compatible version, the 8350.* By 1978, the 8350 had become STC's best selling disk product. (PX 4704, pp. 2, 4, 9; DX 12607, p. 24; see DX 11979.)

(ii) In 1978, STC doubled the capacity of its 8350, announcing the 8650 disk subsystem with a 1.2 billion byte capacity for each two spindle subsystem. (DX 12607, pp. 6, 12.)

(iii) Also in 1978, STC introduced the 4305 Solid State Disk which utilizes charge coupled devices for data storage. According to STC:

"Until recently, the only way to improve machine performance was to choose from three expensive options:

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* STC also responded to IBM's 3350 announcement by reducing prices on its 8000 Super Disk products, originally announced in 1973. (Aweida, Tr. 49347.)

upgrading the central processing unit . . ., add on memory, or add drum storage.

> "STC developed a fourth alternative: the STC 4305 Solid State Disk, which is 134% more efficient, but only 50% of the cost of a fixed head disk subsystem. This new product incorporates operating systems and data based management programs for the newer and larger computers, and allows the user to improve the response and productivity of his present CPU." (DX 12607, p. 16; see DX 11978.)

The 4305 was developed by the STC Systems Division, formed in late 1977 "to develop products on the leading edge of component and systems technology which enables STC to maintain its product leadership in the data processing market." (DX 12607, p. 16.)

By the late 1970s, STC was marketing its "data storage subsystems" to end users of IBM processors and, on an OEM basis, to a large number of systems manufacturers: Burroughs, Univac, DEC, Siemens, CII Honeywell-Bull and "38 others". (DX 12607, p. 24; see DX 11976.)

In addition to tape and disk products, STC continued in the latter 1970s to offer add-on memory for the IBM System/370 line. (PX 4704, pp. 6, 9.) According to STC, its add-on memories "increase throughput and data communications capabilities to a greater extent than similar systems of competitors. They also eliminate the more expensive CPU upgrades." (DX 12607, p. 16.)

STC also moved into new product and technology areas:

(i) <u>"Minicomputer Peripherals"</u>--By 1976, STC had introduced peripherals for "minicomputers" with the announcement of the model 1900 tape drive with a 6,250 bits per inch capacity. (PX

4704, pp. 6, 9.) In 1978, STC announced its 2700, a "very intelligent disk drive" for attachment to "minicomputers". (PX 5601, p. 9; DX 12607, pp. 5, 12.) According to STC, the 2700 contains a built-in microcomputer that can absorb overhead functions from the CPU and a built-in controller permitting most manufacturers to adapt the 2700 for attachment to their processors at low cost. (DX 12608, p. 19.)

(ii) Communications--By 1978 STC had established the STC Communications Corporation in the belief that "the technologies presently being developed by both the data processing and the telecommunications industries are complementary. STC also believes that the industries themselves will overlap greatly in the near future." (DX 12607, p. 22.) In 1978, STC introduced a telephone digital voice multiplexor and concentrator for telephone companies, government agencies and corporate communications networks. According to STC, using microprocessors and special control circuitry, STC's unit can reduce telephone costs by almost 50 percent. (Id.)

(iii) Components--STC foresees increased use of LSI (Large Scale Integration) components in its products. STC, therefore, acquired Microtechnology Corporation in 1979 to assist STC in developing its own LSI devices. (DX 12608, p. 7.) According to STC, if the current trend in price/performance continues, "a 370/168 class computer in a desk-size package at minicomputer prices is feasible by 1985. . . . As these extremely powerful, small, low-cost computers proliferate, so too will the demand for high performance low-cost data storage, and for fast, efficient inter-system communications. To meet that need, STC is funding development in four major areas: components, storage devices, systems and telecommunications." (DX 12608, pp. 23-24.)

j. Xerox Corporation. In the late 1960s, Xerox saw a clear need to acquire digital technology capability for implementation of its advanced information handling systems. C. P. McColough, Xerox's Chief Executive Officer, testified, "As we looked ahead we saw that in future information systems there would be a merging of graphic systems, where we had some experience through our copiers and duplicators and xerographic technology, and digital technology." (PX 5029 (DX 9103), p. 13.) Xerox saw "a great potential . . . not only for more technologically sophisticated copier/duplicators, but for entire information-processing systems of which the copier/duplicator is part." (DX 13399, p. 7.)

With the "primary" purpose of acquiring digital technology for such advanced information handling systems, Xerox decided to acquire an established computer company. As McColough testified, "I was because of a look to the future in some products of a merging of these two technologies, one of which we had, one of which we did not have, that we decided on the acquisition." (PX 5029, McColough, p. 13.) Xerox in fact achieved its objective. It obtained digital technology through the acquisition of a computer company and it uses that technology in its copier and related products. (Currie, Tr. 15596, 15730-31.)

In 1969, Xerox acquired Scientific Data Systems (SDS), a company that had experienced dramatic growth during the 1960s. (DX 45, pp. 3-4.) SDS offered a range of computer systems to perform a variety of applications, including commercial, scientific and time-sharing work. (DX 45, pp. 6-11.) Xerox stated: "The acquisition of a computer manufacturer, Scientific Data Systems, Inc., . . . provides us with a key link in the chain of information services which we feel can lead to great future business." (DX 13399, p. 4.)*

At the outset, Xerox was very optimistic about the prospects for SDS (which was renamed Xerox Data Systems, or XDS). For example, Xerox projected that SDS' revenues would grow from $101 million in 1968 to between $330 and $400 million in 1973 to approximately $600 million in 1976. (PX 5008, pp. 4-5.)**

However, almost from the beginning, Xerox experienced serious difficulties with its XDS operations:

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* Xerox acquired SDS in a stock-for-stock pooling of interest transaction. To acquire SDS, Xerox exchanged nearly 10 million shares of its stock, then valued at approximately $980 million. (Palevsky, Tr. 3195; see also DX 45, p. 3.) That represented nearly 100 times SDS' 1968 earnings and eight times SDS' assets at the time of the acquisition. (See DX 45, pp. 2-3.)

** Secondary to obtaining capability in digital technology, Xerox management initially had a goal of "try[ing] to see if we couldn't reach the No. 2 position in the industry." (PX 5029 (DX 9103), McColough, p. 54.) However, Currie, Data Processing Vice President of XDS, testified that: no steps were taken in the area of marketing "in pursuit of the No. 2 goal" (Tr. 15083); he didn't "recall any development programs that were instituted because of this strategy" (Tr. 15301); "all that was ever seriously done in attaining that strategy was primarily planning activities" (Id.); "precipitated" by declining revenues as early as 1970, "that goal . . . tended to evaporate over a period of time" (Tr. 15095); and the "goal was gone completely by the beginning of 1973." (Id.)

(i) The Recession. While revenues increased to $124 million in 1969, in 1970 revenues declined sharply to $82 million, and dropped again in 1971 to $65 million. (PX 5009, p. 16.) Xerox explained to its shareholders that these results were caused by the recession in 1970 and the decline in government business during this period. (DX 13400, p. 34.) The Xerox witnesses confirmed this in their testimony: Currie testified that the recession "seriously impacted our business"; he estimated that as much as $20 million in revenues were lost as a result. (Tr. 15303, 15334-37.) Cohen testified that the recession and accompanying decline in government spending "caused our revenues to drop quite drastically"; he set the consequent revenue decline at $35 to $40 million. (Tr. 14579; see PX 5029 (DX 9103), McColough, pp. 15-16.)

(ii) Product Obsolescence. At the time of the SDS acquisition, the company's primary product line was the Sigma Series, models 3, 5 and 7. The Sigma 7 was announced in 1966, the Sigma 5 in 1967, and the Sigma 3 in 1969. (DX 13399, p. 11.) Currie testified that the Sigma 5 and 7 reached the peak of their competitive effectiveness in approximately mid-1969 and declined thereafter at an accelerating rate. He also testified that the Sigma 3 reached its peak by the end of 1970 and also declined thereafter at an accelerating rate. (Tr. 15377-83; DX 1000.) Cohen testified that he had used the phrase "tired iron" to describe the Sigma Series, meaning that the "price/performance of equipment . . . no longer provide[s] a significantly competitive posture." According to Cohen, the

Sigma Series "began to manifest its tiredness in 1971." (Tr. 14582-84.) "[A]t least by the middle of 1971 . . . the Sigma 3, 5, 6 and 7 were beginning to indicate their weariness from a competitive standpoint in the marketplace." XDS' "competitors were now bringing out newer higher performing models at better prices which made it much more difficult for the particular models I stated to compete with the competitive models." (Tr. 14580-81.)

Currie testified that "as a reasonable expectation" he would have "liked to have had" replacement products for these computers announced "in the latter part of 1970 with delivery in the first part of 1972." (Tr. 15384.) Cohen testified that replacements for the Sigma 3, 5, 6 and 7 "should have been announced . . . not later than the end of 1972". (Tr. 14584.) Replacements for the Sigma 5, 6 and 7, called the 550 and 560, were not announced until February 1974 and not delivered until the latter part of 1974 or early 1975. (Currie, Tr. 15377, 15383-84.)

By that time, IBM and other manufacturers were already replacing their 1960s product line for the <u>second</u> time in the 1970s. (See p. 1274 below.) In 1970, XDS' Vice President of Development, Montgomery Phister, predicted that product plans which contemplated a postponement of the first shipment of a replacement for the Sigma 5 from January 1974 to July 1975 represented "a potential catastrophe." (Currie, Tr. 15281; PX 419A, p. 2.) According to Currie, the increasing obsolescence of the Sigma line "certainly" had "a significant impact" on the profits of XDS. (Tr. 15361.)

(iii) Manufacturing Problems. Currie testified that Xerox "did have manufacturing problems that increased, I think became particularly acute in the late 1972-1973 time frame, and certainly i the last half of 1972." (Tr. 15304.) He explained that, in the second half of 1972, the manufacturing operation was failing to meet delivery schedules and this "became very severe in 1973." (Tr. 15370-72.) There was "some financial impact" from these problems an "it hurt us, certainly with many of our existing customers." (Tr. 15372-73.)

In Currie's judgment, the "major factors" that caused thes problems were "some basic management problems in manufacturing"* which were "complicated by the fact that" the computer manufacturing facilities in El Segundo were given responsibility for certain non-computer products. He added that Xerox's "manufacturing scheduling/ production control system was not set up for the complexity of products that was put into that factory." (Tr. 15371-72.)

In April 1973, D. E. McKee, then Vice-President of Compute Marketing, wrote to D. T. Kearns, formerly employed by IBM and then President of Xerox's Information Systems Group (now President of Xerox), that the manufacturing operations were unable to meet the demand for products placed on them by Xerox marketing. McKee concluded:

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* Management of the computer manufacturing operations was ultimately replaced. (Currie, Tr. 15372.)

"In my judgment, Manufacturing's priorities and efforts are directed first to copier/duplicator products and secondarily to Computer Products. There does not appear to be adequate motivation for Manufacturing to provide support to the Computer Marketing effort beyond a minimal level." (DX 7929, p. 5.)

McKee stated further that, "the lack of supply, particularly of disks and other peripherals, is impacting our ability to meet our sales and revenue objectives." (Id.) In the same memorandum, McKee told Kearns that the decision had been made some months before to stop purchasing disk drives from CDC and to use Xerox-manufactured disks. McKee noted that "[t]he new drive schedules gradually slipped out" and described the resulting situation:

"To date, we have received only six drives. The second quarter demand is 56. Early this year ITG began to encounter manufacturing problems with the new drives, but assured us that there was a 70% probability that the problems would be resolved in February and a 90% probability that the problem would be resolved and the shipments current by the end of March. As of this date, we have only the six drives mentioned above. Manufacturing is unable to resolve their technical problems and have been unable to commit any shipments. We are presently evaluating outside buys but this cannot solve the problem before 3Q73.

"The disk drive problem has virtually eliminated our ability to make firm commitments on delivery to our customers, aggravated over fifty customers with units on order, made us liable for liquidated damages in some situations and cost us orders for new equipment. Morale in the field is terrible because of delivery schedules and made worse because commitments are missed with no notification from Manufacturing." (Id., p. 2, emphasis in original.)

In August 1973, McKee wrote:

"[O]ur current situation on delivery (disks and controllers particularly but across the whole line) is critical and deteriorating rapidly. We have absolutely no credibility with our own employees or our customers. Even after a firm commitment by you or Ray Hay [Executive Vice President Xerox Corp. (DX 13403, p. 50)], we miss the schedule! We lie to our customers, not once but repeatedly, because we base our commitment on schedules we get from Manufacturing." (DX 7932, p. 1, emphasis in original.)

McKee went on to complain that "when we do get a shipment it is often wrong, incomplete or not in operating condition." McKee stated further that "This is costing us hundreds of thousands in parts, expenses and lost revenue -- but millions in customer satisfaction. . . . During the month of May alone, we were forced to slip over 50% of our customer commitments, many of them more than once." (Id., pp. 1-2.) Finally, McKee wrote that, "Our current outlook is clearly a disaster" and observed that,

> "Ironically, the delivery bind will eventually solve itself because we will lose the on-order business and not get the new orders. Then, ISG will get the blame for missing forecast. I'm telling you, as I have been, that we have a disaster on our hands and no one knows what to do about it or really seems to care. This situation is worse, much worse, now than it was six months ago. . . . I wish I had the answer. I don't think there is one unless and until ITG in El Segundo is made to understand that their jobs depend as much on computers as on copiers and duplicators." (Id., pp. 2, 3.)

(iv) Organizational Changes. In 1972, Xerox changed the organization of its computer operations in a way that hurt their business. Currie testified that in the spring of 1972 "the computer operation was reorganized on a functional basis and made part of the functional area of other parts of the company." (Tr. 15304-05.) After this reorganization, "there was no president of the computer operation per se" and each of the departments of the computer operation were merged with the equivalent function in the Xerox Corporation. (Currie, Tr. 15305-06.) The various heads of the functional departments in turn reported to someone who had no computer experience.* (DX 7640, McKee, pp. 173-74.) At the end of 1973, the computer functions were again reorganized--back into a separate entity called the Data Systems Division. The head of the Data Systems Division never did, however, recover all of the functions that the head of the computer operations had prior to the 1972 reorganization. (Currie, Tr. 15330-31.)

Currie testified that the 1972 functional reorganization of Xerox's computer business had a "negative" impact on those operations, "meaning that the computer business was damaged as a result of this reorganization."** (Tr. 15331.) Currie believed that the reorgani-

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* This reorganization was similar to the way in which Sperry Rand had organized itself during the years 1959-64--and produced similar results. (See above, pp. 155-56.)

** In June of 1973 Currie wrote to T. B. Arneberg, Director of Marketing (Currie, Tr. 14931), that,

> "If you dug deeply into the organization, I think you would find a lot of dissention [sic], dissatisfaction and lack of direction. In spite of the fact that there are three, or really four, functional organizations in El Segundo which should have the same goal, there is little overall leadership pulling and driving these functions toward meeting these hopefully common goals. In my own mind, in spite of the fact that I supported shifting the sales organization to the Regional Vice Presidents, I have concluded the functional organization as it applies to El Segundo is not working and will not work. If this is heresy, so be it. I can find few who are familiar with the El Segundo situation who believe the organization can work in spite of the fact that a lot of us have worked very hard to try to make it successful. A host of problems derive from this basic situation. Morale is negatively affected. Motivation is lacking. Teamwork is virtually nonexistent between functional groups. All of these adversely affect both expense and revenue - and profit." (PX 453, p. 4.)

zation in 1972 delayed the development of products to replace the Sigma Series by "at least six months, probably more like a year." (Tr. 15332.) He testified:

> "the computer business is a very complex business and it is my feeling during this period, that it required the close cooperation, teamwork between the principal managers, it required on-site supervision and decision making in order to operate effectively, and it required total dedication by that group of people . . . to the computer business itself." (Tr. 15331; see also DX 7925, pp. 1, 3; DX 7640, McKee, pp. 171-72.)

(v) Competition. The problems encountered by Xerox's computer operations were, according to the Xerox witnesses, exacerbated by increasingly effective competition. Currie testified that in 1970 "minicomputers were beginning to make inroads on our real time markets and that impacted our business." Competitors in this area included DEC, Varian, Hewlett-Packard, and Data General. Later Xerox "got . . . more serious competition. The IBM 370 line was introduced" and "other companies were coming into the market aggressively." These companies included Systems Engineering Laboratories (SEL) and DEC which "was becoming more aggressive in their larger machines, their PDP 10 line." In addition, Xerox faced increased competition from Univac and Comten during this time.* (Currie, Tr. 15302-04, 15338-40.)

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* The Xerox witnesses identified a variety of competitors that Xerox faced. McKee testified that in the period between 1971 and 1975 Xerox faced the following companies in the manufacture and marketing of computer systems in the United States: IBM, DEC, Modcomp, SEL, Univac, Burroughs, NCR, Honeywell, RCA, Hewlett-Packard, Data General, CDC, Potter, Data Products and "[s]ome of the terminal manufacturers". (DX 7640, McKee, pp. 45-48.) McKee

In July 1975, Xerox announced its "withdrawal from the manufacture and sale of mainframe computers." (DX 13405, p. 8.) This decision reflected Xerox's belief that its "resources should be applied to areas offering acceptable returns to Xerox." (Id., p. 5.) On July 11, 1975, C. P. McColough wrote:

> "Looking to the future, one of the alternatives that we must consider is phasing out of the mainframe computer business but retaining the digital capability we have developed.
>
> "The factors involved are:
>
> "1. The unit manufacturing and service costs of our product line are not competitive.
>
> "2. The computer lease base is becoming increasingly vulnerable and obsolete.
>
> "3. Replacement of the product line would involve hundreds of millions of dollars of expense, capital and cash.

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testified that Xerox competed against minicomputers in situations in which it also competed against IBM 360 and 370 computer systems. (Id., pp. 70-71.) Other competitors during this period included Telefile, Beehive, Hazeltine, Sanders, Mohawk, Tektronix, Centronics, Telex, Computer Machinery Corp., and Gould. (Id., pp. 71-73.) In addition, Xerox competed against leasing companies that leased Xerox manufactured equipment and leasing companies that leased non-Xerox manufactured equipment. (Id., pp. 78-80, 86-87, 91.) Service bureaus were also a competitive alternative to acquiring Xerox computers. (Id., pp. 87-90.) Such service bureaus included Tymshare, Comshare, ADP, SBC, Key Data and XCS. (Id., pp. 92-93.) Finally, there were a number of vendors offering systems to OEM customers of Xerox as an alternative to Xerox systems in 1972, including DEC, Data General, SEL, IBM, Varian, Honeywell, Interdata, Univac, Modcomp, Hewlett-Packard, Burroughs, GE, Lockheed, Texas Instruments, General Automation, Raytheon, CDC, Foxboro, and Tempo (GT&E). (Id., pp. 64-65, see also p. 67.)

Cohen identified approximately twenty competitors, spread across various applications areas. (See pp. 709-10 above.)

"4. The strategic relevance of this product line is less than that of other programs for which we also need funding." (PX 5008, pp. 10-11.)

McColough testified that he was "not aware of any acts of IBM", or any other corporation, "that caused Xerox to make this decision as w did in July of 1975." (PX 5029 (DX 9103), McColough, p. 48; see DX 7640, McKee, p. 37.)

Two additional aspects of Xerox's computer activities should be noted:

<u>First</u>, Xerox was quite successful in replacing its substantial in-house computer installations--comprised largely of IBM, Honeywell and Univac products--with XDS equipment. This conversion effort was paralleled by XDS' efforts in converting non-XDS customers to the company's product line.

<u>Second</u>, although Xerox terminated the "mainframe" portion its computer business in 1975, it by no means left the EDP industry. Indeed, McColough testified that the July 1975 announcement applied to only about half of Xerox's computer business. (PX 5029, McColough, p. 31.) He also testified in early 1976 that "virtually everybody in the computer market one way or the other would be our competitor." He added that Xerox continued to compete with companies marketing computer systems parts of systems and data services. (<u>Id.</u>, pp. 32-34.) In fact for 1975, <u>Datamation</u> ranked Xerox 29th in its "Top 50" survey, with data processing revenues of $80 million; in <u>Datamation</u>'s 1979 survey, Xerox is ranked 12th, with data processing revenue

estimated to be of $475 million. (DX 13657, p. 5; DX 13945, p. 7.) That is more than Xerox's Data Systems Division revenues for the six years 1969 through 1974 combined and three times higher than the 1979 revenues forecast for the division in 1975. (PX 5009, p. 16.)

<u>Xerox's Conversion Efforts.</u> In 1971, Xerox, one of the largest users of IBM equipment in the United States, began to replace its IBM computers, as well as Honeywell and Univac computers installed in-house, with Xerox computers. The first such conversion undertaken by Xerox took place at the regional offices of their copier/duplicator organization. In its 1971 Annual Report, Xerox told its stockholders that, "[w]ithin Xerox a major program is well under way on conversion of the corporation's computer operations to Sigma equipment. Our recently converted regional data centers are now serving as examples of the applicability of Xerox computer systems to the commercial marketplace." (DX 13401, p. 20.)

Xerox had a 360/50, a 360/40 and three 360/30s installed at the five regions, performing applications such as inventory control and field engineering manpower scheduling. (King, Tr. 14756-58, 14814-15, 14824.) In eleven months, Xerox effected the replacement of the IBM computers at the five regions with Sigma 7 computers. The Sigma 7s performed the same applications that had been performed on the IBM computers. (King, Tr. 14762-64, 14824-25.)

After the conversions at the regions, Xerox continued to replace non-Xerox equipment in its internal operations. For example: a Sigma 7 was installed at Research Laboratories in Webster, New York, replacing an IBM 360 Model 44; a Sigma 9 was installed at Rank Xerox in England, displacing a large Honeywell system; and a 360/30 or 40 was displaced at Xerox of Canada by a Xerox computer performing business applications. (King, Tr. 14882-89.)

Xerox expanded the use of its own computers to help run its copier business through the installation in 1974 and 1975 of the Customer Oriented Information Network (COIN). In its 1974 Annual Report, Xerox described COIN as

> "a nationwide computer system that eventually will link every Xerox sales and service branch in the United States with a central information data bank. When complete, this network will handle a range of branch business activities--customer ordering and billing processes, control of parts and equipment inventory--while helping provide faster response to customer needs. Matters that now take days soon will take only minutes." (DX 13404, p. 12.)

The COIN system consisted of Xerox 530 computers and terminals installed at branch and regional locations connected with computers at Rochester. (Currie, Tr. 15447-49.) Currie described COIN as a distributed processing system. (Id.; PX 442, p. 84.)*

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* In January 1975, it was reported within Xerox that "when all funded projects are completed" Xerox computers would represent 95 percent of the total number of computers, by mainframe count, installed in the U.S. operations of Xerox. As of 1975, 133 Xerox computers had been or were to be installed. (DX 997, pp. 9-12.)

By 1972 Xerox's efforts to convert its internal systems to Xerox computers "proved to be so successful that Xerox decided to offer" conversion services "to its customers on a contract basis" through a group called the Applications Services Department, headed by Jack King. (DX 997, p. 102; see King, Tr. 14748, 14751-52; see also Currie, Tr. 15177-78, 15565-67.)

King testified that in the period between 1972 and 1975 his group contracted for and completed approximately 70 to 80 conversions for outside users moving to Xerox computers.* (Tr. 14826-27.) In the course of performing those conversions Xerox displaced IBM computers ranging from 1800s, 1620s and 360/20s to 360/65s and models of the 370 line, including the 145 and 155. Xerox also replaced DEC PDP/8, Univac 1108, CDC 6600, GE 430 and Honeywell 1200 computers. (DX 996D.) King testified that "in many cases", "the bulk", of the displaced IBM equipment was performing business applications. (Tr. 14829-30.)

Xerox's Continuing EDP Business. In 1973, Currie wrote that Xerox Computer Services (XCS), formed in 1970, was "perhaps the greatest asset to come out of the SDS acquisition". He also stated

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* With respect to 40 of these conversions, as to which sufficient information is available, the expenses incurred by King's group in effecting the installation of Xerox computers averaged $97 per program converted. The total conversion expenses incurred by XDS in performing these 40 conversions, involving 10,808 programs, represented 4.83 percent of the total value of the XDS equipment installed as a result of these 40 conversions. (DX 996D.)

that XCS "could form the basis of a major participation in data processing" which "competes very favorably with comparable hardware solutions for routine commercial applications available from IBM and other computer manufacturers." (DX 13402, pp. 22-24; PX 453, p. 2.)

In 1972, Xerox stated that XCS "provides computer time-shared accounting and management services for small- and medium-size companies, as well as for utilities and municipalities." (DX 13402, pp. 22-24.) Xerox advertises that "With Xerox Computer Services, it's possible to get all the information a big computer can supply, without the problems of owning one. . . . Xerox Computer Services has the nationwide communications network, business expertise, and integrated manufacturing, distribution, and accounting applications to handle the toughest jobs for you." (DX 12089; see also DX 12092; DX 12094.)

XCS continued to grow throughout the 1970s and for 1979 Xerox reported that "XCS is a profitable business serving some 200 customers using 2,600 XCS-supplied terminals in 125 cities." (DX 13409, p. 23.) In July 1980 it was reported that XCS, which had entered the hardware business in 1973 when it began to offer terminals designed and built to XCS specifications by Diablo Systems, Inc., had introduced two new terminals, one manufactured by Lear Siegler Corp., and the other by the Office Products Division of Xerox. (DX 14288; see also DX 14289.)*

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* In 1979, Xerox supplemented its service offerings through the acquisition from Itel of AutEx, which operates several systems that disseminate information between buyers and sellers in certain industries. Their largest network "serves brokers, dealers and institutions in the securities busines". (DX 13409, p. 9.)

Beginning in 1972, Xerox acquired a number of companies that manufacture EDP equipment:

(i) In 1972, Xerox acquired Diablo Systems, Inc., a manufacturer of disk units for sale to other manufacturers as well as replacements for IBM disks, printers and terminals. (DX 13402, pp. 34-35; DX 13193; DX 13194; DX 13196.)

(ii) In late-1975, a few months after the discontinuance of the XDS operations, Xerox acquired two companies: Daconics, "a maker of shared-logic word-processing systems utilizing minicomputers"; and Versatec, "a manufacturer of electrostatic printers and plotters". (DX 13405, p. 12; DX 13038.)

(iii) In December 1977, Xerox acquired Shugart Associates for Xerox stock valued at $41 million. Shugart manufactures flexible disk drives and sells them to manufacturers of "minicomputers", terminals and word processing systems. (DX 13407, pp. 10, 32.)

(iv) In 1979, Xerox purchased Century Data Systems (CDS) from California Computer Products for $24 million. CDS manufactures rigid disk drives, which are marketed to original equipment manufacturers who incorporate them into the products they sell. (DX 13409, p. 9.) CDS manufactures a variety of disk drives and controllers that range in size from 10 million bytes to 600 million bytes of storage capacity. (DX 14236.)

In its 1978 Annual Report, Xerox management explained its strategy and direction:

> "Our intended marketplace is vast: It includes all the world's offices and all the conceivable ways-present and future-they might generate, reproduce, distribute, store and retrieve information.
>
> ". . . .
>
> "We are fortunate that Xerox is competing from a position of strength. We are the clear market leader in reprographics, and intend to remain so. We are among the leaders in such areas as rotating memory, facsimile, computer printing and electrography, and we intend to expand those activities. We also bring to the contest a large and well-trained sales and service force, a vast customer base, and great manufacturing and engineering depth." (DX 13408, p. 11.)

Between 1977 and 1979, Xerox introduced a series of products that, according to the company, contain "tiny chip[s] that pac[k] the power of a floor-model computer of a dozen years ago". Those products "create documents . . . communicate information . . . and work with it and process it in digital form." (DX 13407, p. 13.) For example:

(i) In 1977, Xerox introduced two word processing system: the 850 and Visual Type III. Each featured display work stations and substantial processing and text editing capability. (Id., p. 19.)

(ii) Also in 1977, Xerox introduced the 9700 electronic printing system, which employs xerography and other technologies to print 18,000 lines per minute either directly from a computer or from magnetic tape. In 1979, it was reporte that Xerox had begun to offer 6,250 bpi and 1600 bpi tape drives and controllers, manufactured by Storage Technology, for the 9700 (DX 14290; see DX 13407, p. 20; DX 13409, p. 17; DX 12093.) According to Xerox, the "9700 combines computers, which can store any number of different kinds of formats, with the advanced technologies of lasers and xerography." (DX 12090.)

(iii) In 1979, Xerox announced the 860 "information processing system" which "combines text editing and the processing of business office records." (DX 13409, p. 7.) According to Xerox, the 860 "can compute, do statistics and perform the routine work that's essential in managing records, measuring work performance and so on." (DX 14287.)

Over the past two years Xerox has taken several important steps in the area of communications as well:

(i) In 1978, Xerox filed an application with the Federal Communications Commission to provide, through the Xerox Telecommunications Network (XTEN), communications services "for document distribution, teleconferencing and data transmission." (DX 13408, p. 9.)

(ii) In 1979, Xerox completed the acquisition of WUI, Inc., which owns "a worldwide network of telecommunications facilities, including submarine cables and satellites." (Id.; DX 13409, p. 9.)

(iii) Also in 1979, Xerox announced Ethernet which links, through cables, "work stations, printers and electronic files" within a building. Ethernet networks can be linked to one another and to outside communications facilities. (DX 13409, pp. 7, 28.)

In 1978, Xerox described some of the uses of its digital xerographic and communications offerings in government agencies. For example, Xerox reported that "[t]he Executive Office Building, the Senate and the National Bureau of Standards are using our experimental, multi-function Office Information System." According to Xerox, with this system a user, working at a terminal,

> "can electronically compose a document or an illustration in a variety of formats on the screen. At the push of a button, these can be stored in a computer for later retrieval, xerographically converted into plain-paper documents, or sent selectively via an electronic communications network to other users' terminals. The system combines the functions of several separate products: At one work station, the user can create, send, receive, print, draw and file documents." (DX 13408, p. 7.)

Xerox reported that similar experimental systems were installed at the Department of State and the Library of Congress. (Id.)

In 1979, Xerox summarized the progress it had made during the 1970s in achieving its goals.

> "No sooner had Xerox become the world leader in reprographics, than we defined an even larger role for ourselves.
>
> "We wanted to be a leader in making the total business office a more productive environment.
>
> "Reprographics, in our view, would provide the solid foundation upon which we would construct a broader architecture, a total capability to manage office information in all its forms.
>
> "This meant developing capability in the creation,

communication, storage and retrieval of office information, as well as its reproduction.

"Over the past decade we've been steadily developing or acquiring businesses in these critical areas.

"These companies develop, manufacture and market their own products. They market finished products under their own names, or components and peripherals which go into the finished products made by other suppliers of office equipment--the OEM market.

"As independent operations serving their own markets, they contribute substantial--and constantly growing--revenues to Xerox.

"As part of the entire Xerox strategy, these businesses provide the key tools we need to solve the problems of the office.

"We are starting to combine and merge these technologies, working toward the advent--in the not too distant future--of integrated office systems capable of performing all the information tasks in the office environment." (DX 13409, p. 19.)

68. Entry and Expansion of Newer Competitors. The 1970s witnessed the entry of numerous computer systems and equipment suppliers, as well as the expansion of smaller firms that had entered the business in the latter-half of the 1960s.

69. So-called "Minicomputer" Manufacturers. By the mid-1970s, so-called "minicomputers" or "minisystems" had grown in sophistication and power and were already in widespread use as alternatives to larger computer systems and processors from the systems manufacturers which had entered during the 1950s and early 1960s This development was recognized by both users and industry participants at the time. For example:

(i) In 1973, Dr. Ruth Davis of the National Bureau of Standards made these observations on the trends in "minicomputer" use in the early 1970s:

> "As the focal point for computer technology in the federal government, we in the Institute for Computer Sciences and Technology have a special interest in minicomputers. . . . We have seen minicomputers expand their utility from dedicated applications to general purpose systems to systems components in large-scale computer networks. We have seen the federal procurement of minicomputers grow to the point where 48% of the systems acquired in the past fiscal year [1972] were minis (as compared with 38% in the previous year). . . . We have seen new firms enter the minicomputer field--and a few leave--so that there are new [sic] now about 50 different companies manufacturing minicomputer main frames." (DX 5346, pp. 1-2.)

(ii) In 1973, Douglas A. Crone, Deputy Director of ADP Procurement of the GSA, testified:

> ". . . there's a wider choice of computer capability available, and you use, now, the capability that matches what you need. In some instances, it's more economical to

provide a mini-computer at a number of--or several mini-computers at a number of locations rather than have a centralized, large system. . . . Other times, even today, it's better to have a centralized system with terminals. I mean, a lot depends on your applications. . . . It has opened up the choice of 'Shall you have one big system, or a number of systems with terminals', or 'Do you want to decentralize to small systems'." (DX 9071: Crone, pp. 130-31.)

(iii) In 1975, Hindle from DEC testified that "in a given computer application a customer could choose one powerful machine to do the job or could choose several less powerful machines and decentralize the job". Hindle also said that customers with multiple locations "usually" have "as a competitive alternative . . . a single large system which would have remote terminals" or "multiple smaller systems". (Tr. 7415-16, 7500-01.)

(iv) Richard Bloch, formerly with GE, testified about the industry trend that he saw in 1969-1970 toward "movement of the computing function from the larger processor to smaller processors", and stated:

"There is now a distinct move toward utilizing these smaller processors, which are smaller physically, they are smaller dollarwise, but they certainly aren't smaller in terms of power when contrasted to the earlier days." (Tr. 7764-68.)

(v) In 1971, Data General's management reported that:

"Minicomputers are being used increasingly in applications that formerly employed either large, sophisticated computers or simple, special purpose electronics. Supported by extensive software and peripheral equipment, small computers have become performance-competitive with large computers in many applications." (DX 13507, p. 5.)

(vi) NCR reported in 1976 that "smaller systems to an increasing extent are replacing the large central processors which historically have paced the growth of the data processing industry". (DX 2760, p. 14.)

(vii) Honeywell stated, in 1977, that:

> "There was a time when state-of-the art limitations forced users to place all their computer resources at a distant central site, and then to adjust their business operations to meet the restrictions imposed by such centralization. That's changing today. Users now want to be able to distribute the power of the computer in the ways that best fit their needs, with as much--or as little--centralization as is required. . . . Distributing the computer's resources can serve as an effective management tool for today's business requirements." (DX 3705, p. 127.)

According to Honeywell, users had at least "three representative" types of distributed systems to choose from, including a "hierarchical system", with a "host processor", a "horizontal distributed processing" system with "an 'equal partner' relationship" among processors or a "hybrid system", combining elements of the other two. (Id., pp. 133-38.)

(viii) Hewlett-Packard stated in 1978 that one of the important industry trends

> "is a change in the way computers are being used. Large mainframe computers, operated to their full capabilities, become inaccessible and less well suited for many of today's applications. There is a growing interest in distributing some of the processing load away from these central mainframes to smaller computers at key locations throughout an organization. These smaller computers can serve as the only data processing resource of a department or small division or they can be linked together into a network of computers which can communicate with one another." (DX 12335, p. 6; see also Weil, Tr. 7257-58;

Beard, Tr. 10050-51; Hangen, Tr. 10433-34, 10851-52, 11326; O'Neill, Tr. 77067-71; J. Jones, Tr. 78903-07; DX 467A (Tr. 15795-96); DX 3710, pp. 95-99.)

A number of the 1960s systems suppliers, including Burroughs, CDC, Honeywell, NCR and, of course, Digital Equipment, had been offering smaller computers for sometime. Some began calling their new small computers "minicomputers". (See pp. 634, 1069 above.) These manufacturers obviously recognized the attractiveness of smaller, general purpose computer systems that could be used in "distributed" configurations, either interconnected into a single system, used in stand-alone applications or used in mixtures of both and sought to capitalize on the trend.

In addition, the list of companies that entered the industry by making "minisystems" or "minicomputers" continued to grow. For example:

a. <u>Data General.</u> Data General was formed in April 1968.* The company announced its first product, the "Nova" computer system, in the fall of that year and began product shipments in February 1969. Its first offices were located in a store front in Hudson, Massachusetts. (DX 14215, pp. 1-2.) Data General's original capitalization was less than $1 million. (<u>Id.</u>, p. 15.) In 1970, the company raised $3 million from a public offering of common stock and obtained a $3-1/2 million credit line from several banks. (DX 13886, pp. 1, 12.) In 1971, Data General raised about $15 million from additional sales of common stock. (DX 13507, p. 3.)

Data General's first revenues, in 1969, totaled approximately $1 million. (DX 14215, p. 1.) In 1970, domestic EDP revenues were $6.8 million. (DX 8224, p. 140.) By that year, the company's second full year of operation, it had become profitable and, according to management, "made the transition from a new venture to one of the five largest manufacturers of mini-computers." (DX 13886, p. 1.)

In 1971, the company's EDP revenues in the U.S. climbed to $14.1 million; in 1972, they were up to approximately $25.8 million. (DX 8224, p. 140.) In 1973, Data General's worldwide revenues were about $53 million. (DX 12307, p. 3.) By fiscal 1979, Data General's worldwide revenues had reached $507 million, making it the 441st

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* Three of the company's founders--including Data General President, Edson deCastro--were former DEC employees.

largest industrial firm in the United States as reported in the Fortune 500 listing--up from the 500th position in 1978. (DX 13946, p. 292.) Revenues for the first three-quarters of fiscal 1980 were reported to be $439.8 million, a $100 million increase over revenues for the same period during fiscal 1979. (DX 14419.)

In 1979, Data General's management described the company's business this way:

> "Data General Corporation designs, manufactures and sells general purpose digital computers and computer systems ranging from under $100 to over $750,000, related products, including peripheral equipment, software and software services, training and maintenance." (DX 12310, p. 3.)

The company's first product, the NOVA computer system, was described by the company as "a 16-bit word, small-scale, general-purpose digital computer. Its basic price is $7,950, including 4,096 words of core memory and a teletype interface." (DX 14215, p. 11.) The NOVA processor was designed to operate with as many as 60-odd peripheral devices. (DX 14215, p. 11.) The NOVA was an immediate success. By the end of 1970, Data General had delivered over 700 NOVA computers. (DX 13886, p. 1.)

In early 1970, the company began shipments of its second product, the Supernova, which it described as "the fastest mini-computer in its class" (DX 13886, p. 1); the product quickly won acceptance for applications "requiring a large number of peripherals and fast computing speeds". (Id.)

In 1970, Data General introduced several new products:

(i) the Nova 800 and 1200 processors, which were more powerful than the original Nova, and capable of using Data General's existing line of peripheral products. (DX 13886, p. 5.)

(ii) the Multiprocessor Communications Adaptor, or MCA, which "permits a user to combine up to fifteen Novas and/or Supernovas into a single multiple computer system which allows any computer to transfer data to any other computer in the system through a common communications bus". (DX 13886, p. 5.)

(iii) a hardware/software interface to IBM System/360 and System/370 processors that "permits the Nova line of computers to be treated as standard IBM peripherals by the 360 or 370 system. This product is particularly important to large IBM customers and to system developers who have peripheral devices or terminals that they wish to interface to a System 360 or 370." (DX 13886, pp. 3-5.)

(iv) the Supernova SC processor, built with monolithic, as opposed to core, main memory. (Id., p. 7.)

In the years 1971 through 1973, Data General continued introducing new products and also brought in-house the manufacture of an increasing percentage of the products it marketed. For example:

(i) In 1972 and 1973, Data General opened a core manufacturing facility and later, a semiconductor manufacturing facility. (DX 12307, p. 5; DX 14244.)

(ii) Data General also began to manufacture IBM 2311-type disk subsystems for use in its computer systems. (DX 12307, p. 11; see also DX 14243.)

(iii) In 1973, the Nova 840 and Nova 2 processors were added to Data General's product line. (DX 12307, p. 3.) Data General called the Nova 2s "a line of computers that can handle the complete range of computer applications, from running small, dedicated computer tasks to supporting a full complement of peripheral equipment and software. Nova 2s have been sold for scientific instrument control, computer equipment testing and business data processing". (DX 12307, p. 9.) The Nova 840 was advertised by Data General as having "the most comprehensive set of hardware/software capabilities ever offered by Data General. . . . It is widely used in demanding timesharing, Batch, real-time and data communications applications." (DX 6925, p. 3; see also DX 12307, p. 3.)

By 1974, Data General's computer systems were being used for a variety of data processing tasks, including:

(i) the control of traffic signals and various industrial jobs (DX 12308, p. 6);

(ii) applications requiring computation, such as numerical applications performed in universities, engineering firms and research laboratories and also in "large organizations that build an in-house time-sharing service around a small computer system". (Id., p. 12.) In these applications the Data General systems performed tasks that "would be much more costly if done manually and which would cost several times more if large, central computer systems were used". (Id., p. 12.)

(iii) use as front-end processors and back-up processors to host processors in larger computer systems. The example given by Data General was a computer performing front-end functions in a large credit card authorization network. Questionable account files and lists of stolen credit cards were stored on the Data General computer. The applications performed on the Data General computer would otherwise have been performed in the host processor. "Soon after the Data General computer was installed, the large host computer faile The authorization application could continue "even though the host computer was not operating." (Id., p. 16.)*

By 1974, Data General systems were also used as intelligent terminals in computer system configurations where processing was distributed, rather than centralized. For example:

(i) The Fruehauf Corporation used Data General computer systems to process and transfer information among over 150 offices and its corporate headquarters in Detroit. (Id., p. 14.)

(ii) Television stations used Data General CPU's as part of intelligent terminals for tracking and scheduling commercia

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* Welch of Chemical Bank testified that Chemical performs a credit card application using a Data General Nova and associated peripherals. (See p. 1350 below.)

time slots, a sophisticated form of inventory control. (Id., p. 18.)

Closely related to the use of these computers as intelligent terminals is their use in what Data General then called "data systems". For example:

(i) A U.S. building materials chain used Data General computers in its "order building, inventory checks and invoicing" applications. (Id., p. 20.)

(ii) Air France used Nova 800 computers to assign passengers seats on international flights. (Id., p. 20.)

(iii) Citibank reportedly used Data General Nova 840s for the purpose of performing income tax processing services for New York City. (DX 14293.)*

Also in the early 1970s, Data General won what was to become a large order in competition with IBM. The Southern Railway was looking for ways to perform the company's "waybilling" applications at its railroad yards. IBM and Southern began a joint study in one yard, using a large central processor--an IBM 370 Model 158 installed in Atlanta--and "dumb" terminals at the yard. Beginning in 1972, however, Southern chose to install Data General equipment at its yards, first for yard control and then for inventories, waybilling and other applications. (See pp. 1448-57 below.) Beginning in 1972 with a purchase of $500,000 worth of Data General equipment,

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* See the discussion of the testimony of Welch, p. 1344 below and the discussion of DX 9403, pp. 1510-14 below.

Southern has undertaken to acquire, by the end of 1980, over $7 million worth of Data General equipment in a distributed computer network--in lieu of using the IBM proposed "centralized" system. (See pp. 1436-37 below.)

In 1974, Data General expanded its computer line further with the introduction of the Eclipse series. This "family" was itself enhanced and expanded throughout the Seventies. (See DX 12308, p. 4.)

Through 1977, the range of data processing jobs for which Data General's systems were being selected continued to expand. For example, Data General's management reported that:

(i) In Sweden, Data General installed a "network of 14 NOVA and ECLIPSE computers to provide user-oriented interactive data processing at a substantially lower cost than that of an equally powerful large computer installation". (DX 3527, p. 11.)

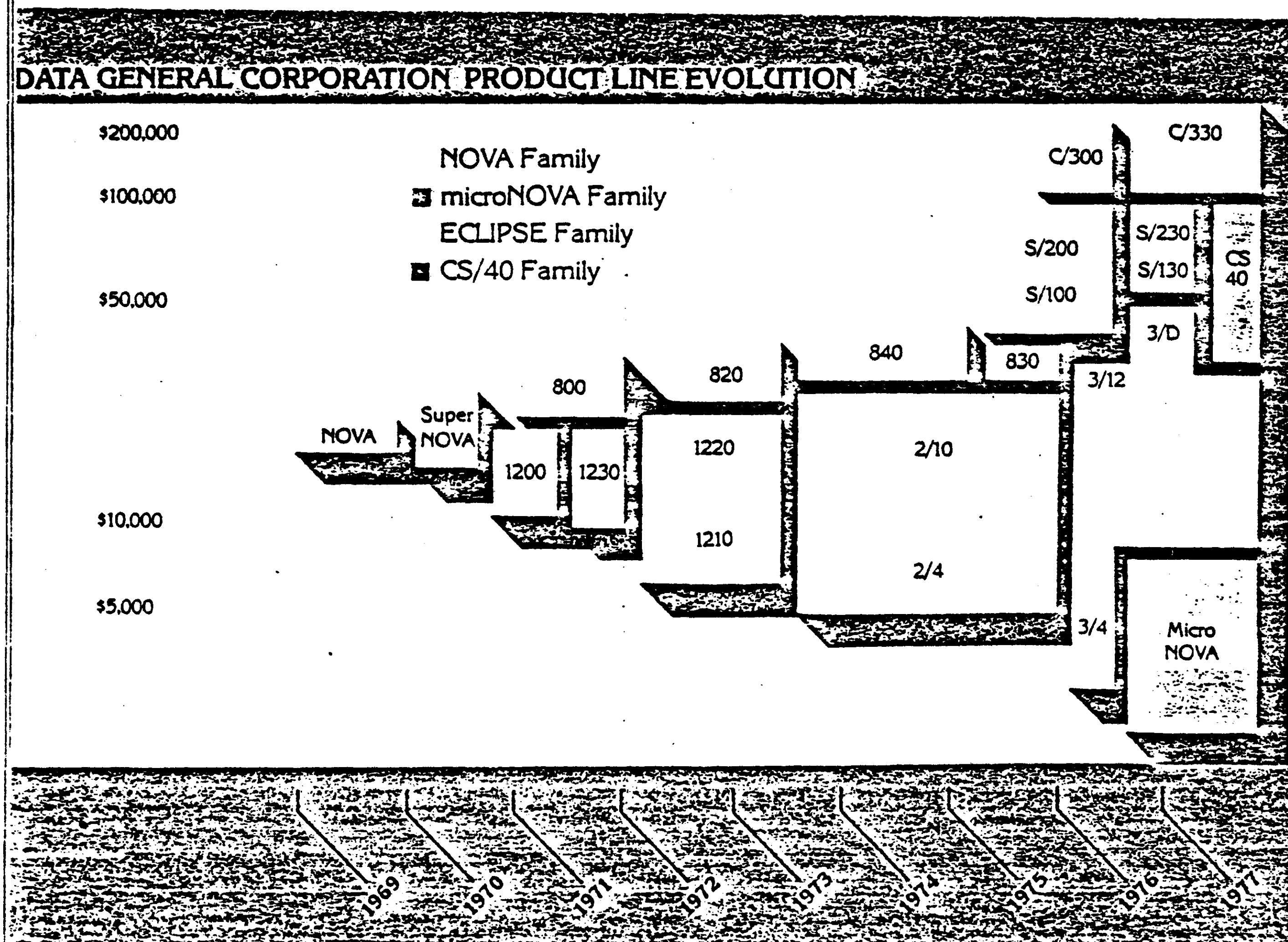
(ii) Data General "replaced a large central computer with a distributed system built around a commercial Eclipse C/330" at Continental Forrest Industries in Louisiana. (Id., p. 13.)

(iii) "Some typical applications" for the ECLIPSE C/300 systems include:

> "Inventory management systems. Product distribution systems. Production management systems. Law enforcement systems. Sales management systems. Personnel management systems. Credit management systems. Purchasing systems. Maintenance service systems. Hospital patient care systems. Insurance claim systems. Portfolio management systems. Stockholder records systems. General ledger

systems. Pension fund management systems. Budgetary planning & control systems. Project management systems. Mortgage loan service systems. Property management systems and Student administration systems." (DX 12788, p. 18.)

The company's 1977 Annual Report (DX 3527, p. 6) contained the following illustration of the "Data General Corporation Product Line Evolution":



In January 1978, Data General introduced the Eclipse M/6 computer system, with a purchase price of $500,000 or more. (DX 11398; DX 12309, pp. 1, 13.) According to Data General, the M/600 supports up to 2 million bytes of main memory and up to 6 billion bytes of on-line disk storage. It uses the AOS operating system, which permits users to "perform timesharing, batch and real-time data processing operations simultaneously." The M/600 also suppor a variety of programming languages such as PL/1, FORTRAN, and COBO and Data General's data base management system. (DX 14223A; DX 14247; DX 14401; DX 3527, p. 9; DX 12309, p. 15; DX 11404; DX 1139 The Eclipse computers, including the M/600 also use Data General's "XODIAC networking system that allows users to manage large number of computers interconnected into networks and to access large commercial data processing networks." (DX 12310, p. 8; DX 11669.)

The Eclipse M/600, as well as Data General's earlier Eclipse and Nova line computers have been marketed in direct compe tion with the products of IBM and others. In addition to the exam ples discussed above, these additional examples are illustrative:

(i) IBM salesmen reported a win over Data General at Hartford Insurance Group; IBM's successful bid--a 370/168; Da General's losing bid--40 Eclipse/300 "Minicomputers". (PX 6467, Vol. 4, February, p. 5.)

(ii) Also reported by IBM's salesmen, a loss of an IBM p posed 370/148 and four IBM 370/138s to eight Data General M/6 at Baker & Taylor in New York. (PX 6467, Vol. 5, April, p. 1

(iii) IBM employees have also reported internally that "[t]he M/600 is often in competitive situations involving the DEC PDP 11/70, HP 3000 Series II, and IBM S/370 models 125 through 148. It will also be seen in competition with the DEC VAX/780." (DX 13276.)

(iv) In June 1979 it was noted within IBM that the M/600, as well as the Data General C/350, were among the systems that had "been active against the 4331" during April and May 1979. The M/600 was rated as having 1.6 times the performance of the 4331. (DX 9407; see also DX 11404.)*

In May 1980, Data General announced the MV/8000 which is advertised as supporting up to 2 megabytes of main memory, 6.6 billion bytes of online disk storage, 128 terminals, and a number of programming languages and other software. (DX 14246; DX 14245.)

In addition to expanding its Eclipse series upward, Data General has also introduced new small computers. For example, in 1977 Data General introduced its Commercial Systems (CS) line. Data General describes the CS/40 as:

> "a family of business information processing systems for small-to-medium size applications. CS/40 computers are used by departments and regional offices of large corporations, often as part of distributed corporate information processing networks. CS/40 systems are also used by small businesses in the $500,000 to $20 million revenue range to fulfill their entire information processing needs." (DX 3527, p. 7.)

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* As already noted, the IBM 4331 processor is a 370-compatible processor, with the power roughly of an IBM 370 Model 138. (Akers, Tr. 96692.)

The CS line, which has been expanded both upward and downward since 1977, supports COBOL and can communicate with other Data General processors and the processors of other manufacturers. CS systems range in price from $20,000 to $150,000. (Id., DX 12310, p. 18; DX 11397.)

b. <u>Prime Computer, Inc.</u> Prime Computer, Inc., was formed in 1971 and began operations in February 1972. (DX 5917, Baron, pp. 3-4.) Total capitalization at the end of 1972 was less than $1.6 million. During 1973 Prime raised an additional $1.2 million through various private placements. Between 1972 and 1974 Prime devoted its efforts principally to development of its product line, streamlining of its manufacturing operation and establishment of a "worldwide sales [and] service" organization. (DX 13901, pp. 4,5,13.)

Prime characterizes its business as "the design, manufacture, sale and service of small and medium-size general purpose digital computers and interactive computer systems". (DX 14219, p. 46.)

Prime's first computer was the Prime 200; the company's first year of revenues was 1972--with revenues amounting to $12,000. (DX 12999, p. 9; DX 13901, p. 8.) By 1974, its total revenues were about $6 million. (DX 12373, p. 6.) In 1979, its revenues had risen to about $153 million, and the company was ranked 38th in data processing revenues by <u>Datamation</u>. (DX 14219, p. 37; DX 13945.) Prime's revenues for the first quarter of 1980, as reported in the trade press, were $52 million, which was an increase of 77 percent over their first quarter revenues of 1979. (DX 14273.) As of March 1980, Prime reported that more than 3,500 Prime computer systems were in use around the world. (DX 14219, p. 6.)

Prime's investment growth curve during the 1974-1979 period is also noteworthy. In 1974, Prime had total assets of $7.5 million. By 1976 that had increased to almost $20 million; and by 1979 to $142.7 million--almost twenty times the investment of 1974. (DX 14219, pp. 36-37; DX 12373, p. 7.) By 1979 Prime had expanded its production capacity to support volume levels in excess of $300 million a year. (DX 14219, p. 28.) The investment necessary for this expansion came from retained earnings and a variety of financing arrangements, including a $25-to-$45 million line of bank credit, sale of common stock, and the issuing of $20 million of convertible debentures. (Id., pp. 3, 39; DX 13901, p. 5.)

According to Prime, by 1977, the "top" of Prime's line of systems, the Prime 400 and Prime 500, provided up to 8 million bytes of main memory and up to 2.4 billion bytes of on-line disk capacity. That disk capacity was available on drives offering up to 300 million bytes of storage each.* The 400 and 500 were also capable of supporting up to 63 concurrent users and offered programming in various languages, including FORTRAN, COBOL, BASIC and RPG II. In addition, they supported a CODASYL-compliant data base management system. (DX 12997, p. 1; DX 11900; DX 11901; DX 11897.)** The Prime 500 is marketed as being "equally adept

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* Prime also offers a broad line of other peripheral products, including: floppy diskettes; matrix, chain and band printers; card readers and punches; magnetic tape drives; plotters; and paper tape readers and punches. (DX 12998, pp. 2-14.)

** A description of the "CODASYL Committee" and its data base management specifications is provided by Withington. (Tr. 56513-16.

at interactive business data processing and computational timesharing. It simultaneously supports up to 63 users involved in such diverse activities as RJE, forms processing, on-line data entry, computational timesharing, and data base management". (DX 12999, p. 9; DX 11901; DX 11897.) With respect to "instruction execution times for single- and double-precision floating point arithmetic", Prime says that its 500 system is "comparable to those of the considerably more expensive IBM 370 Model 158". (DX 14229, p. 2; DX 11901.)

In addition, Prime offers communications and networking capabilities through "PRIMENET", which is marketed as providing "complete local and remote network communication services for Prime systems. In geographically dispersed network configurations, it allows Prime computers to communicate with other Prime computers, with computers from other vendors, and with terminals attached to packet switching networks". (DX 14228, pp. 1-2, 8.)

In January 1979, the same month as IBM's 4300 series announcement, Prime announced four new computers, compatible with one another--the Prime 450, 550, 650 and 750. (DX 12373, p. 5.) The largest, the Prime 750, is offered with up to 8 megabytes of main memory, a variety of programming tools, such as COBOL, FORTRAN, PL/1 and Prime's data base management system. (DX 11907; DX 14230, pp. 2, 4, 6, 8, 10.) The 750 is marketed by Prime for:

> "huge computational analyses, big data processing tasks for business, and complex data communications applications. . . . Also, the same 750 that runs your business programs can simultaneously crunch some very big numbers. And since its

likely that distributed processing will be part of your plans, the 750 is supported by an exceptionally wide range of networking software, including our own PRIMENET, which allows local and remote communications, and supports the X.25 international packet switching protocol." (DX 11907; DX 11903.)

Prime reported that as of March 1980 "[a]bout half" of its installed computers "are used in scientific/engineering computation and a similar number for interactive business data processing". (DX 14219, p. 6.) One Prime brochure gives examples of particular customer applications performed by Prime's systems:

"[a] large New England medical center uses a Prime 300 to access and modify cardiac data";

"[a]n automobile manufacturer uses a Prime 400 computer system for in-house timesharing and remote job entry";

"[a] West Coast aircraft manufacturer uses three Prime 300 systems for data reduction from aircraft acoustical tests";

"[a]n international communications company uses two Prime systems to switch messages between its New York City headquarters and its worldwide communications network"; and

"[a] California aerospace company tests spacecraft components with its multiuser Prime system". (DX 12999, p. 12.)

Prime's product line, although developed, announced and delivered only with the last few years, already represents a sophisticated and powerful "family" of general purpose computer systems that are competitive alternatives to a range of IBM computer systems, for the performance of a wide variety of applications.

For example:

(i) In 1977 Prime emphasized that its "interactive data processing systems . . . quite literally provide mainframe functionality at less than one-tenth the price. They are designed to coexist with your present computer so you can optimize its batch processing performance by letting a Prime system off-load on-line interactive tasks". (DX 11900.)

(ii) Also in 1977, Prime marketed its systems as providing "number crunching performance in the same league as the [IBM] 370/158". (DX 11901.)

(iii) Of its newer 750 system, Prime stated that the system can perform a variety of different tasks, including sophisticated data base management and "is also a multi-role building block for distributed processing"; Prime added: "the 750 is still priced well below mainframes of comparable capabilities, and it's a lot less costly to install, operate and support". (DX 11903; see also DX 11907.)

(iv) In 1979, Prime advertised its products as alternatives to IBM's newest 370 "mainframes", the 4331 and 4341 processors: "if what you really need is 4300 capability, you can have it in 90 days. From Prime Computer". The ad invited users to: "Compare performance. Our Prime 750 and 550 have outperformed IBM's 4341 and 4331 in computational benchmarks". (DX 14272.)

(v) In July 1979, it was noted within IBM's sales organization that the Prime 750 was among the computers that had "been active against the 4331 during the months of April and May". (DX 9407.)

c. Perkin-Elmer (Interdata). Perkin-Elmer is a diversified manufacturer of analytical instruments, optics equipment, and avionic instruments as well as "small and medium scale computers and peripherals". (DX 12372, p. 2.) Perkin-Elmer's corporate-wide revenues were $733 million for fiscal 1979, well over twice its revenues of just five years earlier. (Id., pp. 32-33.) In 1979, Perkin-Elmer ranked 347th in the Fortune list of the top 500 industrial organizations in the United States. (DX 13946)

In 1974, Perkin-Elmer acquired Interdata, a manufacturer of "minicomputers", which was founded in 1966. (DX 12367, p. 3; DX 3994, Alznauer, p. 3.) In 1976, Perkin-Elmer further expanded its EDP product line through the acquisition of Wangco, a peripheral equipment manufacturer. (DX 12369, pp. 2, 10.)*

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* In 1977, Perkin-Elmer described Wangco this way:

> "Formed in 1969 as a magnetic tape drive supplier, Wangco is now the largest independent supplier of low-cost magnetic tape drives and a leader among magnetic disc drive manufacturers. Wangco products are known for their high quality, reliability, and user convenience.
>
> "Wangco markets its mass storage devices primarily to product and system OEMs. The superior performance of Wangco tape and disc systems in a wide range of applications has resulted in their wide acceptance by OEMs throughout the world. Wangco products are incorporated in distributed data processing systems, remote batch terminals, data entry systems, data communications systems, optical character readers, data collection systems, and minicomputer systems." (DX 12993, p. 11.)

In 1977, Perkin-Elmer's management explained the company's expansion into computers as "a logical extension" of its earlier business:

"When Perkin-Elmer management contemplated further expansion in the early 1970's, they decided to search for a new growth area compatible with the company's current technologies and future directions. The new area of activity was to be large enough to be meaningful, growing rapidly, sufficiently predictable to justify a major long-term commitment, and most importantly--consistent with Perkin-Elmer's established reputation for technological excellence.

"Perkin-Elmer's expansion into the computer field was natural. For as long as the company has been in existence, it has managed highly technical businesses. The data systems field is clearly appropriate to Perkin-Elmer's technological and management orientation." (DX 12993, p. 4.)

During the period 1974 to 1979, Perkin-Elmer's EDP business experienced substantial growth. In 1974, the revenues of the company's Data Systems Group were $41.7 million; in 1979, they were up to $168 million. (DX 12371, p. 5; DX 12372, p. 7.) The company was ranked 33rd in data processing revenues in 1979, by Datamation. (DX 13945.)

Underlying that growth was Perkin-Elmer's expansion and enhancement of Interdata's computer product line. In 1975, the firm introduced the 8/32 "Megamini" computer and began delivery of the 7/32 computer. Perkin-Elmer described the 7/32's performance as "roughly equivalent to the IBM System 370/135." (DX 12996, p. 16.) Of the 8/32, the company stated:

"The 8/32, with 1 million bytes of directly addressable memory, is positioned at the point where the traditional minicomputer market intersects the large scale mainframe computer market. It combines the advantage of large scale mainframe architecture and performance with minicomputer packaging and pricing and is ideally suited to a broad range of applications. The 8/32's first customers are using it for flight simulation, seismic data processing, commercial data processing and distributive data processing." (DX 12368, pp. 12-13.)

According to Perkin-Elmer, in addition to main memory expandable to one million bytes, the 8/32 supports over one billion bytes of on-line disk storage and a variety of programming languages such as COBOL, FORTRAN and BASIC. In 1977, "TOTAL", the sophisticated data base management system developed by CINCOM Systems, was made available for the 7/32 and 8/32 systems. (DX 2795; DX 12996, p. 17-18, 33; DX 2826-A; Withington, Tr. 57667-68.)

By 1977, Perkin-Elmer could report that it offered its customers "a broad array of complementary computer and peripheral products":

"- a family of small and medium-scale computers, from a low-cost 16-bit, single board processor to a powerful 32-bit computer system, and a full range of operating systems and high level languages.

"- a complete line of magnetic tape drives, formatters, cartridge disc drives, controllers, moving-head disc subsystems and floppy disc drives.

"- a range of smart printer-terminals with exceptional forms-handling capabilities and superior print quality, a low-cost basic CRT, and a versatile editing CRT terminal.

"Beyond its basic product line, Perkin-Elmer Data Systems offers a full complement of other peripheral devices, development software, applications software, interfaces, communications options, and a variety of integrated systems." (DX 12993, p. 8.)

In these years, 1975-1978, Perkin-Elmer continued to market its systems in competition with IBM and other systems suppliers. For example:

(i) In 1975, Interdata 8/32s were selected by First National City Bank in New York, as that customer moved to distributed data processing as an alternative to larger IBM 370 processors. (See PX 6467, Vol. 2, October, p. 12; DX 9403, pp. 28-29; see Welch's testimony, discussed below, p. 1344; see also Akers, Tr. 97770-72; Withington, Tr. 55809-10.)

(ii) In 1978, Perkin-Elmer advertised that it had benchmarked its 8/32 system against and out performed an IBM 370/158. Perkin-Elmer's systems were offered to perform a variety of "FORTRAN number crunching" jobs with mainframe precision and convenience". (DX 11885.)

In February 1979, within a month of IBM's 4331/4341 processor announcements, Perkin-Elmer announced the first of two new computer systems, the 3220. In September of 1979, the second, the 3240, was announced. (DX 12372, pp. 7-8.) The 3240 is reported as supporting up to 16 million bytes of main memory--the same capacity available at the top of IBM's line, the 3033--and up to 115 billion bytes of on-line disk storage. (DX 11886.)

The 3240/3220 series is being marketed for such diverse applications as:

(i) "scientific computation, real-time flight simulation and data acquisition, financial transactions, inventory control and similar commercial-industrial applications involving the rapid processing of large amounts of data" (DX 12372, p. 12);

(ii) "simulation", "high-performance transaction processing, such as an on-line reservation system", "scientific research", "command and control or computer-aided design applications" and on-line program development. (DX 11886; DX 11887.)

d. Harris Corporation. Harris Corporation* was founded in 1895. (DX 14251.) Until the early 1970s, its principal business was the manufacture of typesetting and other printing equipment. In 1969, Harris began deliveries of the Fototronic-CRT typesetter, a "computerized cathode ray tube unit". (DX 14217, p. 8.) That product was soon followed up with additional systems to perform typesetting and other applications related to the printing business. (See DX 7303, pp. 1-6; DX 7304, pp. 2-6.)

Through two major acquisitions in the early 1970s, Harris greatly expanded its participation in the computer industry:

(i) In 1971, Harris acquired a minority interest in Datacraft Corporation, a manufacturer of computer systems, in the range of the PDP 11 and IBM System/360 Model 50, and of core memory for its own processors and for IBM System/360 processors. (DX 4909, ¶ 18, p. 7 (Stipulation); Hindle, Tr. 7403; DX 6792, pp. 1-2; DX 6791.) In January 1974, Harris acquired Datacraft Corporation by purchasing the remainder of Datacraft's outstanding stock. (DX 3993, p. 24.)

(ii) In 1972, Harris acquired CSI, a subsidiary of UCC, which is now Wyly Corporation. CSI manufactures programmable communications controllers compatible with IBM processors, as well as a line of terminals, printers and card readers.

* Harris changed its name from Harris Intertype Corporation to Harris Corporation in 1974. (DX 3899, Wach, p. 4.)

(DX 3899, pp. 5-6, 33, 36; DX 7260-7272.)

In 1979, Harris described its computer product line in Forbes this way:

> "Harris offers a complete family of high-performance, general-purpose computer systems. Providing virtual memory, data base management and a multitude of languages for scientific and commercial applications." (DX 11569; see also DX 12333, p. 6.)

By the end of fiscal year 1979 (June 30), Harris' corporate revenues had grown to $982 million from $280 million in 1971 and the company had achieved the position of 290th in Fortune's list of the 500 largest industrial companies in the United States. (DX 12330, p. 3; DX 12333, p. 29; DX 13946, p. 286.) Based on Datamation's estimates, Harris' worldwide data processing revenues in 1979 were $210 million, putting it 28th in its ranking. (DX 13945.)

In the years 1976 through 1979, Harris introduced a series of new computer products, including computer systems, front-end processors and terminal equipment. For example:

(i) In 1976, Harris enhanced its Model 1600 "remote communications processor", first introduced in 1972. These enhancements, according to Harris, opened "up many new applications involving remote data entry, inquiry-response and increased local data processing." (DX 12330, p. 9.) These "new applications" are generally performed in distributed data processing configurations.

(ii) In June 1977, Harris introduced additions to its Series 100 computer line, consisting of "three new high-performance, medium-scale computer systems", the 115, 125 and 135. (DX 2746, p. 1.) At the time of the announcement of these computers Harris stated that

> "[t]he three new systems, designed primarily for the end-user market, incorporate new technology hardware extensions of the highly successful Harris Series 100 System, coupled with the field proven VULCAN Virtual Memory Operating System. VULCAN can concurrently support timesharing, multi-stream batch, remote job entry and real-time operations." (Id.; see also DX 12913, pp. 2-4.)

According to Harris, the Series 100 systems could also support a variety of languages including COBOL and FORTRAN and the TOTAL data base management system. The 135, capable of supporting "a multitude of complex commercial and scientific applications", was expandable to 768 thousand bytes of main memory and utilized Harris' 300 million byte disk unit. (DX 12912, pp. 2-3, 6; DX 12920.) At the time of its announcement, Harris stated that a System 135 with 672 thousand bytes of main memory, 2.4 billion bytes of disk storage, additional peripheral equipment and the TOTAL Database Management System was priced at approximately $835,000. (DX 2746, p. 3.)

(iii) In 1979, Harris again enhanced the 1600 "distributed data processing product line" by introducing a faster new processor with double the memory capacity of the previous 1600, which permitted "simultaneous execution of all five distributed data processing functions--remote batch, local batch, data entry, local interactive and remote interactive processing". (DX 12333, p. 6; see also DX 12908, pp. 1-10.)

(iv) In 1978, Harris introduced the "high-performance" Series 500 computer family, consisting of the 550 and 570 systems,

> "a family of powerful, disc-oriented virtual memory computer systems for the educational, scientific and industrial end-user. Each system can perform concurrent interactive time-sharing, multi-stream batch, remote job entry and real-time processing. Series 500 systems provide cost-effective solutions for your distributed data processing, transaction-oriented processing, management information and communications problems." (DX 12923, p. 2.)

According to Harris, 500 family systems support the TOTAL data base management system and can be configured with over 3 million bytes of main memory. (DX 12923, pp. 2-3; DX 11564.)

(v) In 1979, Harris introduced the Series 800 consisting of the 850 and 870 systems, which are "software compatible with the Harris Series 100, 200 and 500 computer lines". (DX 12333, p. 6.) The 870 system can support up to 128 interactive terminals simultaneously. (Id.) The 850 processor is marketed with memory expandable to over 3 million bytes. (DX 12910.) Both Series 800 "models can perform a wide range of computer functions including concurrent time sharing, multi-stream batch, remote job entry and real-time processing." (DX 12333, p. 6; see also DX 12910.)

e. <u>Wang Laboratories, Inc.</u> Wang Laboratories was founded in 1951. It first marketed EDP products in 1964, and by 1972 its U.S. EDP revenues were reported as about $30 million. (DX 8224, p. 132.) Wang's total corporate revenues in that year were $39 million. (DX 12403, p. 4.)

By fiscal 1979, however, Wang's revenues were $321 million, up from $198 million in fiscal 1978. (DX 12405, pp. 2, 4-5.) The company's data processing revenues that year were $280 million, based on <u>Datamation</u>'s estimates, putting it 23rd in the ranking. (DX 13945.)

In addition, Wang's orders increased from $232 million in fiscal 1978 to $415 million in fiscal 1979; and Wang's 1979 backlog increased 133 percent over the previous year. (DX 12405, p. 2.) For the first six months of fiscal 1980, Wang's revenues were reported as $219.7 million, an increase of 68 percent over revenues during the similar period of the prior year. (DX 14286.)

Little wonder Akers testified that in his view Wang was "coming on like Gangbusters". (Tr. 97135.) Wang was able to finance its growth through three public offerings of stock from 1977 to 1979 (DX 12405, p. 2), including $22 million from common stock offerings in October 1977 and August 1978. (DX 12404, p. 3.)

In 1979, Wang's management described the evolution of the company's product offerings over the preceding decade:

"From early desktop calculators, programmable calculators and typewriter-based word processing systems, Wang products have evolved into small business systems, medium-to-large-scale computers, CRT-based word-processing systems, Image Printers and phototypesetting equipment. With each new development, the Company has addressed an ever-expanding market." (DX 12405, p. 10.)

The company's current business is described as the design, manufacture, marketing and servicing of "computers and related peripheral devices which are combined into (a) information processing systems for use in business, technical and scientific applications and (b) word processing systems". (DX 12405, p. 16.)

Wang's major line of computer systems for "information processing" has been the 2200, first introduced in 1973. (DX 12403, p. 3.) In the past three years, Wang has enhanced the 2200 line substantially.

In October 1977, Wang introduced the 2200VS, described as "having multiple terminal, multiple language, and improved programming capabilities". According to Wang, the 2200VS can support "up to 23 workstations and 2.3 billion bytes of on-line disk storage". (DX 12405, p. 16; DX 12072.) The 2200VS is offered with 512,000 bytes of main memory. (DX 12075.)

By 1979, Wang's computer systems were reported in use for a variety of data processing tasks. For example:

(i) A Wang VS system replaced a Burroughs B1700 system at a Volkswagen service center in Connecticut, where the user was quoted as saying: "We've put everything in our business onto our VS system, including payroll, accounting, sales and wholesale and retail inventory control". (DX 12072.)

(ii) E.F. Hutton installed a "cluster" of Wang systems fo in-house time-sharing, "capable of handling a variety of data processing and analytical functions. And capable . . . of servicing Hutton's entire brokerage staff nationwide." (DX 12074.)

(iii) In the Imco Container Division of Ethyl Corporation, a Wang "MVP multiprocessing computer" is used to design "the custom bottles they manufacture" and "to simultaneously serve other departments and other applications. . . ." (DX 12404, p. 6.)

(iv) At KLM, Wang systems are performing or are planned t perform personnel functions, maintenance scheduling and program development applications. (DX 12405, p. 9.)

(v) AT O.M. Scott & Sons, Wang VS systems, equipped with IBM 3780 equipment software protocols, "are used for remote job entry, as distributed processors, and for local applications". A VS system located at the "main warehousing facility is used to prepare bills of lading" and to collect, edit and transmit certain data to a "mainframe" computer. (Id., p. 6.)

In June 1979, five months after IBM's 4331 and 4341 processor announcements (see p. 1335 below), Wang introduced an additional member of the 2200VS family--the VS-100, described as "supporting up to 128 workstations and expanded disk storage capacity to 4.6 billion bytes". The VS-100, which sells for up to $800,000, has "multiprocessing capabilities" utilizing several languages and supports "a variety of telecommunications options and data base management software". (DX 12405, pp. 3, 11, 13, 16.)

In September 1979, Wang's management stated that the company's "major competitive strength" was in "Business systems", specifically in the $10,000 to $800,000 price range". (DX 12405, pp. 18-19.) Wang's "Major competitors" at the "higher end" of that business were said to include "larger IBM System 3 configurations, the low end of the IBM 370 line, the IBM E Series 4331 and 4341 and the IBM 8100, Digital Equipment Corp. (PDP 11/34-11/70 series), Data General's CS 20/40/60 series and Eclipse series, and Hewlett-Packard's 3000". (Id.)

Wang has consistently marketed its products in competition with IBM. For example:

(i) Wang marketed the 2200 VS as "The bigger giant killer"--an alternative to DEC, Data General and IBM equipment, including IBM's "System/34, System/3 [and] 370/125". (DX 12071.)

(ii) In 1979, Wang claimed that its VS systems out-performed and "won order[s]" from IBM "System 34's, 3's, 360/370's, HP 3000II's, DEC 11/70's, Prime, Honeywell and Burroughs" machines. (DX 12075.)

(iii) In 1979 and 1980 Wang has actively marketed its VS systems in competition with IBM's new, 4331, 4341 and System/38 systems. (See DX 12076, DX 12077, DX 12078, DX 12079.)

f. Tandem Computers, Inc. Tandem Computers, Inc. was formed in 1974, with an initial capitalization of $217,250 and raised approximately $2.3 million more through private placements by December 1975.* (DX 13918, pp. 4, 23-24.) The company shipped its first computer system in May 1976. (DX 12394, p. 8.) Since that first shipment, its revenues have grown from $581,000 in fiscal 1976, to $7,692,000 in fiscal 1977, to $55,974,000 in fiscal 1979. (DX 12395, p. 31.) Tandem's revenues for the first half of its 1980 fiscal year were reported to be $45 million, twice its revenues for the equivalent period during the previous year. (DX 13947.)

In 1979, Tandem was ranked as the 69th largest company in data processing revenues by Datamation. (DX 13945.)

Tandem's computer systems consist of multiple processors that operate as a single system. Its systems are expandable from a basic two-processor system to a system utilizing sixteen processors.**

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* In December 1977, Tandem raised approximately an additional $8 million from its first public stock offering. (DX 12394, p. 5.)

** According to Tandem, its use of multi-processors permits "Non-Stop" operation because in the event of a processor failure, another processor automatically takes control of the work being performed. (DX 13030, p. 7; DX 11996.) In 1979 Tandem described the scope and capabilities of its NonStop system:

> "The Tandem NonStop System is the first general purpose, commercial computer system designed specifically to fulfill the critical needs of on-line transaction processing. The innovative, fault-tolerant Tandem architecture virtually eliminates the risk of system failures and protects the customers' data

(DX 12394, pp. 34-35; DX 12395, p. 5.) According to the company, each Tandem processor supports up to 2 megabytes of main memory, large disk capacity (for example, a 10-processor Tandem system can support 9.6 billion bytes of on-line disk), a variety of programming languages, including COBOL and FORTRAN, and a data base management system.* (DX 13918, pp. 15-16; DX 12395, p. 5; DX 11991; DX 11992; DX 11995; DX 13027; DX 13030, pp. 7-9.)

Also, Tandem offers the EXPAND network operating system that permits users to "build a distributed data processing network of up to 255 geographically dispersed Tandem systems . . . ." (DX 12395, p. 5.) Under EXPAND, the network can grow as large as 4,080 processors, each one capable of accessing a geographically distributed data base as if it were located in the local system. (DX 13030, p. 7.) According to Tandem,

> "With EXPAND, there need be no host computer, as in other networks, that can fail and jeopardize the data or continued operation of an entire network. Each Tandem processor in a geographically dispersed network sustains its own data integrity and performance integrity. Under EXPAND, any Tandem processor in the network can communicate directly with any other without costly point-to-point communications between all systems. Tandem systems are also certified to communicate on X.25 public

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bases from damage caused by electronic malfunctions. The system is also the only one on the market that can be expanded modularly--without any programming changes and even while the system is running--from a two-prooessor, mid-sized system up to a 16-processor, large-scale system, creating a continuous range of models priced from approximately $150,000 to over $3,000,000." (DX 12395, p. 5.)

* Tandem does not manufacture its own peripheral equipment, but acquires that equipment from OEM suppliers. (DX 12395, pp. 23-24.)

or private packet switched networks which can further reduce communications costs. And, in the event of a communications line failure, EXPAND automatically reroutes communications and the network stays on the air." (DX 12395, p. 12; DX 11995.)

Tandem systems are employed for a wide range of data processing tasks. For example:

(i) During fiscal 1979, "systems were shipped to customers in 25 industries. Banks and manufacturers each accounted for approximately 14% of shipments. Other major economic sectors that purchased Tandem systems included medical, service bureaus, non-bank financial institutions and national governments." (DX 12395, p. 16.)

(ii) The Blue Cross and Blue Shield Associations employ 22 Tandem processors in seven cities connected to 200 terminals located in 100 regional offices around the United States to perform data collection for all Medicare claims, eligibility determination and other applications. (Id., p. 7.)

(iii) The Illinois Central Gulf Railroad utilizes Tandem computers to perform waybilling and yard management applications for some 50,000 freight cars. (Id., p. 12.) Jones of the Southern Railway testified that a number of railroads have chosen to perform the same applications using a variety of competitive equipment: Santa Fe uses an IBM 370/145 at one yard and a Univac 1106 at another; Missouri Pacific uses DEC equipment for some functions and an IBM 370/168 for waybilling; and Seaboard Coastline uses Modcomp equipment at three of its yards. (J. Jones, Tr. 79280-88.)

In June 1979, six months after IBM's 4300 series computer announcement, it was stated in IBM that Tandem computers were among the systems that had "been active against the 4331 during" April and May. According to that IBM report, the Tandem system offered 2.5 times the performance of a 4331. (DX 9407.)

g. <u>Datapoint.</u> In 1969, Datapoint introduced its first product, a solid-state terminal used as a teletypewriter replacement in computer systems. (DX 12314, p. 10.) Since that time, Datapoint has introduced a variety of processors, communications equipment and software, emphasizing throughout the distributed data processing capabilities of its products. The scope and capability of Datapoint's product offerings have increased substantially.

In the past three years, Datapoint has introduced a number of significant products:

(i) In 1977, Datapoint announced the "6600 Advanced Business Processor, which substantially increased the capabilities of the top of the product line". The 6600 was "intended for more sophisticated stand-alone processing, timesharing with up to 24 terminals, and network applications". (DX 12312, pp. 6, 10.)

(ii) Also in 1977, Datapoint introduced the Attached Resource Computer (ARC), which Datapoint described as follows:

> "The ARC System concept is a completely modular architecture that enables a totally integrated computing facility consisting of an almost unlimited number of interconnected small Datapoint processors and peripherals--all with access to each other and to a common, dispersed database. Until December 1977, 'dispersed' data processing usually meant geographic dispersion; now, with the ARC System, functional dispersion of computing power throughout a company's offices makes economic sense.
>
> ". . . .
>
> "In the ARC System, individual processors are designated as either file managers or applications processors; these can be almost any Datapoint processors, although we

have introduced two series of processors designed specifically for the ARC System environment. A customer's IBM 360/370 mainframe computer can also function as an ARC System applications processor." (DX 12313, pp. 12-13; see also DX 11415.)

According to Datapoint,

"In an ARC system, many different types of applications--data entry, batch or transaction processing, database inquiry, communications--can be done concurrently yet with maximum efficiency, and without hampering any user of the system by the activities of any other.

"An ARC system provides small and large businesses alike with the processing power and common database featur of a large computer combined with the upgradability and task-oriented flexibility of functionally dispersed small computers.

"Three basic components of an ARC system are: applications processors, which perform batch or transaction processing tasks in either single or multiuser modes; file processors, which are dedicated to managing data on data storage units to locate and deliver remotely stored data on demand to applications processors; an interprocessor bus consisting of hardware and firmware physically connected by inexpensive coaxial cable to provide an extremely high-speed electronic pathway for data transfer." (DX 12805, p. 1.)

In Datapoint's ARC System, certain processors are designated as "applications processors" and others as "file processors". Applications processors "accomplish the entry and processing of data", while "[f]ile processors are dedicated to the management of data on magnetic disk files." File processors perform the function of managing and supplying the data that is accessed and used by the applications processors. (DX 12798, pp. 3-4.)

According to Datapoint, ARC supports a variety of programming languages, including COBOL, RPG and BASIC, as well as DATASHARE "for multi-user, on-line transaction processing" and Datapoint networking software. (DX 11415, p. 3.) Datapoint markets the ARC as the "best of both": the "one-big-computer approach" and the "many-mini approach". (DX 11420.)

(iii) In 1978, Datapoint introduced the Datapoint Attached Support Processor (DASP), which is marketed to provide IBM 360 and 370 computer users "with full batch teleprocessing capabilities . . . without requiring costly upgrading of the mainframe and without disturbing the mainframe's existing local processing capacity". (DX 12495.)

Datapoint's general purpose computer systems have been reported by IBM salesmen in direct competition with IBM computer systems and products. (See, e.g., PX 6467, Vol. 1, December, p. 11; id., Vol. 2, October, p. 12; id., Vol. 3, August, p. 5.) In one IBM study (discussed at some length on pp. 1516-21 below), Datapoint 6600s at a particular account were discussed as follows:

> "The 'minis' will grow both in number and size in the future. As per the December 5, 1977 Computerworld article, Datapoint's ARC (Attached Resource Computer) system will have multiple processors connected together and providing various networking functions. Pepsicola is heading in this direction, growing each single 'minicomputer' installation into multiple connected minicomputers.
>
> "The growth in workload will come from increased current application activity plus implementation of new applications." (DX 9409, p. 117.)

The growth of Datapoint's product line has been accompanied by an enviable corporate growth. In fiscal 1979, Datapoint's revenues were $232 million, a nearly seven-fold increase over its fiscal 1974 revenues of $34 million. (DX 12311, p. 2; DX 12314, p. 4.) Datamation ranked Datapoint 26th in its 1979 data processing revenue survey. (DX 13945.)

70. "Plug-Compatible Processor" Manufacturers. Beginning in 1975, with the first shipment of a "plug-compatible" processor by the Amdahl Corporation, a new type of competitor in the computer industry emerged. Since that time, additional manufacturers have begun to make and market computer processors that use IBM's software and may be "plugged into" IBM or IBM-compatible peripheral equipment to replace an IBM-manufactured processor, much as "plug-compatible" storage or input/output equipment is marketed to replace "compatible" IBM peripheral equipment.

a. Amdahl Corporation. Amdahl Corporation "was founded in 1970 to develop, manufacture and market large-scale computer systems for general purpose applications". (DX 12267, p. 1.) The principal founder of the company was Gene Amdahl, who had been one of IBM's chief processor designers for the System/360 and who left IBM to start his new company. (Withington, Tr. 55876-77; Bloch, Tr. 92992.)

As of 1975, the two principal stockholders in Amdahl were the Japanese computer manufacturer Fujitsu, with a 41 percent interest,* and Heizer Corporation, with a 31 percent interest. The remainder of Amdahl's stock was owned by many other investors, including Allstate Insurance, Employers Mutual Liability Insurance

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* Amdahl has maintained a close working relationship with Fujitsu. Fujitsu manufactures major subassemblies used in the fabrication of Amdahl's computers. In addition, Amdahl and Fujitsu operate a 50/50 joint venture for the marketing of Amdahl computers in countries other than the U.S. and Canada for which Amdahl has exclusive rights, and in Japan and Spain for which Fujitsu has such rights. (DX 4354, pp. 3-4; DX 12267, pp. 26-27.)

Company of Wisconsin and Nixdorf Computer. (DX 4354, p. 2.)

By the end of 1974, $45 million had been invested in Amdahl. (Id.) In 1976, the company received approximately $25 million from a public stock offering and converted $31 million of convertible debentures into common stock. (DX 12267, p. 2.)

In mid-1975, Amdahl introduced its first product, the 470 V/6 processor, the first IBM-plug-compatible CPU. It was designed as a one-for-one replacement for the IBM 370/168 processor, at that time IBM's largest, most powerful computer. (DX 3525; DX 4354, pp. 1, 4; DX 12267, p. 1.) These Amdahl processors, much like "plug-compatible" storage and input/output equipment of companies such as Intel, STC or Memorex, make use of existing IBM-designed systems control programming. Hence, Amdahl customers are able to use IBM's operating system software as well as IBM and IBM-compatible peripheral equipment. Computer systems with an Amdahl processor may have no IBM-manufactured hardware included in them, and no connection with IBM except the IBM-created system control programming. (DX 4354, p. 1; see Goetz, Tr. 17429, 17679, 17778-79, 18777-78; Wright, Tr. 13225-27, 13232-36.)

Amdahl's IBM plug-compatible processors met with immediate success in competition with IBM:

(i) In the latter half of 1975, Amdahl sold several systems and reported $14 million of revenues for the year. (DX 12267, pp. 20-21.) A 1975 IBM study of 119 large system customers found that 40 percent of the accounts were considering

Amdahl as an alternative to their IBM processors and that there was Amdahl "sales activity in virtually all of [the] 119 [accounts.]" (DX 9399, p. 13; see Akers, Tr. 96905-06, 96908-09.) Akers testified:

> "At this particular time, our customers were enjoying the opportunity of large processors available from Amdahl that were both better performance and better priced than IBM's processors . . . ." (Tr. 96905-06.)

(ii) In 1976, the first full year of product shipments, Amdahl achieved $92.8 million of revenues and reported that "this initial year--as measured by financial criteria, product performance, and market acceptance--compares favorably with any previous new business's first full year of sales, as well as with the performance of many long-established enterprises". (DX 12267, pp. 1-2.)

(iii) In 1977, Amdahl's revenues increased 103 percent to $188.8 million, despite a reported 29 percent price reduction on the 470 V/6-II processor, in response to IBM's price and product actions (DX 12268, p. 4; DX 14482.) Amdahl's price reduction reportedly resulted in significant gains in demand, and shipments more than doubled over the level of the preceding year. (DX 12267, p. 6; DX 14483.)

(iv) During 1978, Amdahl again achieved healthy revenue growth, reaching $320.9 million. (DX 12268, p. 4.)

In 1977 and 1978, Amdahl introduced several new processors, all reportedly IBM plug-compatible: the 470 V/6-II processor, comparable to the 3032; the 470 V/7, comparable to the IBM 3033; the 470 V/5, comparable to the IBM 3031 and 370/168-3; as well as the 470 V/5-II, and the 470 V/8, its most powerful processor, comparable to IBM's 3033. (DX 3525; DX 9140, p. 10; DX 13076; DX 14344.)

In addition to its expanded hardware offerings, in 1978 Amdahl began to market software enhancements for its product line, including operating system performance enhancements called the MVS/SE Assist and the VM/Performance Enhancement. (DX 12268, pp. 8, 11; see also DX 13078; DX 13080.) In 1980, Amdahl reportedly announced that it would begin to market certain of its software to users of IBM computer equipment that did not use Amdahl processors. (DX 14343.)

Amdahl's 1979 revenues reportedly dropped slightly, to $299.6 million. (DX 14323.) The revenue decline was anticipated by Amdahl, which had reported to its stockholders in its 1978 Annual Report: "[W]e believe that we will experience [in 1979] a higher percentage of leases versus sales than we have had in the past. To the extent customers decide to lease rather than to buy our systems, revenues and earnings will be spread into the future." (DX 12268, p. 5.)

b. <u>Others.</u> Since the introduction of Amdahl's 470 V/6, other companies have brought out IBM-compatible central processing units. Together, those companies, with Amdahl, offer users in the United States, Japan and Europe plug-compatible replacements for IBM

CPUs that range from the IBM 8100, 370 processors, the 4300 Series and up to the 3033.

Several of these offerings are discussed elsewhere in this testimony:

National Advanced Systems manufactures and markets IBM-compatible processors, previously marketed by Itel, that offer performance equivalent to IBM's 4300 Series and 3031/3032 processors and they market a processor manufactured in Japan by Hitachi in the 3033 range. (See p. 1207 below);

Nixdorf announced in May 1980 that it plans to offer a 4331-compatible system in the United States. (See p. 1273 below.)

In addition to this activity, a number of other companies have begun developing and marketing IBM-compatible processors. Among those companies are CDC, Magnuson Systems, Two Pi, Nanodata, Paradyne and others discussed below.

(i) Control Data Corporation. In May 1977, CDC announced six models of two IBM-compatible computer systems, called the Omega 480-I and Omega 480-II, which, according to CDC, were in the 370/135 through 148 performance range. (DX 2269.) CDC also stated at the time of their announcement that Omega systems could "be configured with Control Data plug-compatible peripherals that include disk, tape and printer subsystems, and the CDC 38500 Mass Storage System". (Id., p. 1.) By August 1977, CDC had reportedly installed the first Omegas. (DX 2792.) Withington testified that CDC offers complete computer systems incorporating their IBM-compatible central processing units. (Withington, Tr. 56387; DX 2594A.)

CDC's Omega processors were developed and are manufactured by IPL Systems, Inc. (DX 2269, p. 3.)

In March 1979, it was reported that CDC announced the Omega 480 Model 3, manufactured by IPL, said to be in the performance range of IBM's 3031. It was also reported that prices for the Omega 480 Models 1 and 2 had been reduced in response to IBM's recent product announcements. (DX 14348.)

(ii) Magnuson Systems Corporation. Magnuson was founded in 1977. The company reportedly started off with $1 million in venture capital and received $4 million from Fairchild Camera & Instrument Co. in 1978 in exchange for 19 percent of Magnuson's stock and convertible notes. (H. Brown, Tr. 83873-74; DX 14442, p. 2 DX 13721; DX 14365.)*

In May 1978, Magnuson reportedly announced the first models of its M80 line of IBM-compatible central processing units, said to be compatible with the IBM 370/138 and 148. (DX 13721.)

In March 1979, Magnuson announced three new IBM-compatible central processing units and reduced prices for its original processors and memory. The new processors reportedly exceeded the performance of IBM's 4331 and 4341 processors. (DX 14366 ; see DX 11748;

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* In July 1979, it was reported that Magnuson had raised an additional $10 million through a private placement. According to that report, Magnuson succeeded in raising twice as much money as it had originally sought to raise. (DX 14364.)

DX 11749; DX 11750.) According to Magnuson, with its new processors, it could offer alternatives to the entire mid-range of the IBM line, from the 370/138 to the bottom of the 370/158 class. (DX 14403.)

(iii) Two Pi Co., Inc. Two Pi, a subsidiary of Philips of Holland* (see DX 14404), manufactures IBM plug-compatible central processing units in the performance range of IBM's 370/138 and 4300 Series processors.

In April 1978, Two Pi reportedly announced its first plug-compatible processor, the V32; that processor can support up to four million bytes of main memory. (DX 14404; see also DX 9410, p. 10.)

In May 1980, Two Pi announced that it had added integrated controllers to the channels of its V32 processor, which reportedly "enabl[e] it to attach a variety of non-IBM compatible peripherals" such as "Control Data and CDC-compatible storage module drives; Pertec 8000 and Pertec-compatible tape units; Documation RM-Series card readers; and Dataproducts 2200-Series printers." (DX 13249.)

Two Pi markets the V32 on an OEM basis to other companies. Two Pi's first customer was National CSS, which markets the V32 as part of its 3200 system. (See DX 9410, p. 10; DX 14404.)**

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* In 1978, Philips had over $15 billion of sales and ranked fifth in the Fortune Directory of the 500 largest industrial corporations outside the United States. (DX 8053.)

** It is interesting to note that both NCSS and the trade press refer to the V32 as a "minicomputer" or "supermini". (DX 11821; DX 12647, p. 2.) NCSS calls its 3200 "the mighty mini with mainframe muscle". (DX 14368.)

In January 1979, Computerworld reported the announcement that Time Sharing Resources, Inc. (TSR) would market the V32 along with TSR developed systems and applications software. (DX 13243.) In May 1979, Two Pi reportedly signed a contract with Semiconductor Systems Pty. Ltd. to supply over 100 of its V32 processors, to be distributed in Australia. (DX 14381.) In May 1980, it was reported that Two Pi had shipped in excess of 100 V32 processors, most of which had gone to National CSS. (DX 13249.)

(iv) Nanodata Computer Corp. Nanodata was formed in 1971 and, at first, engaged in advanced research and development activities; as a result of those activities, Nanodata developed the QM-1 Emulator. According to Nanodata, the QM-1 "can assume the identity of any computer, becoming exactly like the emulated machine down to the most minute detail". (DX 11820.) It has been reported that QM-1 can emulate IBM, DEC and Data General Computers, as well as computers of 23 other companies. (DX 11819; DX 14116: DX 14367.)

In 1978, Computerworld reported Nanodata's announcement of two IBM-compatible systems in the 370/138 and 148 performance range. (DX 14405.)

In June 1980, it was reported that Nanodata introduced the IBM-compatible QMX 6300 series, which consists of three models in the 4331 and 4341 performance range and can be configured with up to 4 million bytes of main memory. (DX 14383; see DX 12620.)

(v) Paradyne Corporation. Paradyne Corporation has expanded its product offerings from modems, its first product introduced in 1971, to communications and network controllers of the IBM 3705 type and to IBM-compatible computers. (DX 13895, pp. 8-10.) Paradyne achieved good corporate growth in the latter half of the 1970s with revenues increasing from $2.6 million in fiscal 1974 to $41.4 million in fiscal 1979. (DX 13895, p. 24; DX 13896, p. 3.) For the first quarter of 1980, Paradyne's revenues reportedly climbed to $14.8 million, an 85 percent increase over the same period for the prior year. (DX 14412.)

Three of Paradyne's recent offerings, PIX II, PIXNET and the RESPONSE system, have significantly broadened the company's product and market coverage.

PIX II*, whose design is "based on the use of a microcoded mini-computer", provides communications capability permitting the interaction of remote terminals and IBM or IBM-compatible processors. Using PIX II, communications are handled without the need for IBM communications controllers or "communication software programs in the host computer". (DX 13895, p. 6.) According to Paradyne, "[f]rom 25% to 40% of valuable mainframe processor power may be required in managing the teleprocessing network". Paradyne's PIX systems off-load that processing function from the "host processor". (DX 13896, p. 10.) Paradyne also provides terminals and other peripheral devices that can be installed at remote sites. (DX

* PIX II was introduced in 1976 and represents an upgrade to Paradyne's original PIX system, introduced in 1973. (DX 13896, p. 10.)

13895, pp. 8, 10.)

PIXNET, announced and delivered in 1979, incorporates all of the capabilities of PIX II and provides additional functions necessary for coordinating a network. PIXNET permits PIX II systems "access to multiple applications and multiple computers in the network, where all devices and applications can communicate simultaneously and continuously". (DX 13896, p. 10.)

In late 1979, Paradyne announced the RESPONSE system. It employs an IBM 370 instruction set and, according to Paradyne, is aimed at IBM users. (DX 13896, p. 12; DX 13934.) Paradyne describ the RESPONSE system as providing "the full power and performance of a mainframe". (DX 13896, p. 12.)

In its 1979 Annual Report Paradyne commented on the future of the marketplace:

> "[T]he market for data communications products will more than double by 1985. This can be attributed to the vastly improved price/performance ratios on computer and communications systems, together with the increased demand for distributed data-processing . . . systems.
>
> ". . . .
>
> "Not only has the growth rate of data communications been rapid, but due to a merging of communications and data processing technologies, it is logical for companies in communications to enter data processing markets and vice versa." (Id., p. 6.)

PIXNET and RESPONSE were apparently motivated by this "merging". Paradyne explained that since it had "already developed all of the communications systems necessary to distribute data to geographically remote points, it made sense for Paradyne to extend its expertise one step further into the broader market area of distributed data processing". (Id., p. 1[2].)

(vi) Others. There has been additional activity reported recently in the development of IBM-compatible central processing units. For example, in March 1980, it was reported that Formation, Inc. had introduced "an off-the-shelf minicomputer system" that it said equals the performance of an IBM 370/158. The Formation 4000 Information System, expandable to 4 million bytes of main memory, was reported to consist of "multiple microprocessing units, micro-coded to emulate IBM 370 channels and controllers". Formation stated that the 4000 System could utilize IBM software, was compatible with "the entire 370 program library" and could "accommodate the DOS/VS, OS/VS1 and VM 370 operating systems". (DX 14354.)

In April 1980, it was reported that an Israeli company, Elbit, which is 37 percent owned by CDC, would begin production of a family of IBM-compatible computers in the 370/125 to 148 range. An Elbit executive was reported to say that the new series would be "370 software-transparent and plug-compatible, with the capability of using both IBM and small computer peripherals, as well as IBM's DOS/VS and OS/VS1". Elbit was reported to be planning to market its new processors in Europe and the United States. (DX 12609.)

71. Semiconductor Manufacturers. During the 1970s, advances in semiconductor technology played a major role in lowering the price and increasing the performance and reliability of computer equipment. (See, e.g., E. Bloch, Tr. 91752-53; DX 467A, p. 8.) Semiconductor components are manufactured by a large number of companies, including computer equipment manufacturers like IBM and many others. For example, IBM's Erich Bloch identified Texas Instruments, Fairchild, Motorola, Intel, Mostek, Advanced Memory Devices, Hitachi, Fujitsu, Philips, and National Semiconductor as being in the "component industry". (Tr. 91690-92; see also DX 341, p. 4; DX 398, p. 11.)

A number of semiconductor component companies have expanded into the manufacture of computer equipment. Two of the more recent examples are Intel and National Semiconductor, discussed below. Another is Texas Instruments, which expanded at a relatively early time into the manufacture of EDP products.

Texas Instruments' corporate revenues in 1979 exceeded $3.2 billion. (DX 12402, p. 1.) TI was one of the "major companies" involved in the early "development of transistors for commercial purposes". (Fernbach, Tr. 469-70; see Case, Tr. 73248.) Since that time, TI has marketed a broad range of computer equipment, including, in recent years, the DS990 "Commercial Computer System" and the TI Series 700 "Distributed Processing Systems". According to TI, the 990 computer system supports over two million bytes of main memory, a data base management system and programming languages such as COBOL, FORTRAN and BASIC. (DX 12036.) As part of its Series 700, TI offers a family of intelligent terminals, disk storage, printers, and bubble memory devices. (DX 12030; DX 12032.)*

a. Intel Corporation. Intel Corporation, founded in 1968 (DX 5926, Jordan, p. 6), describes itself as the "leading supplier" of large-scale integrated circuits. (DX 12343, p. 1.) Intel capitalized on its capabilities in the fabrication of semiconductor memory and large-scale integrated circuits to expand beyond the production of semiconductor memory circuits to microprocessors and to complete memory systems, including IBM and DEC plug-compatible memory systems. The company's revenues have climbed from $4.2 million in 1970, to $134.5 million in 1974, to $663 million in 1979. (DX 14332, p. 1.) By 1979, Intel was ranked 368th in the Fortune 500 directory, up from the 486th position just one year earlier. (DX 13946, p. 290.)

In its 1977 Annual Report, Intel described the evolution of its product line this way:

> "After pioneering semiconductor memory, Intel developed the concept of the microprocessor, or the 'computer-on-a-chip' in the early 70's. Microprocessors, now available in several families, have caused a rapid expansion of the use of LSI components by extending electronic solutions to a vast range of new problems. Even for simple chores, such as appliance control, the cost of microprocessors has fallen to a level making them the preferred solution. As a result,

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* TI markets the 700 Series to "speed up your data traffic and process jobs on the spot instead of tying up your mainframe". (DX 12032.)

applications are expanding rapidly. Intel has led in developing and serving the microprocessor market from the beginning.

> "Intel's capability in LSI components has opened business opportunities in equipment with high LSI content. The first of these we pursued was complete memory systems for sale both to original equipment manufacturers and to end users. Here again, Intel has become the leading independent supplier of semiconductor memory systems." (DX 12343, p. 1.)

Intel's microprocessors are used in a variety of products. For example, Intel advertises that its microprocessors are employed in Wang word processors, Hazeltine terminals and Aydin video graphics terminals. (DX 14257; DX 14258; DX 14259.) Intel has enhanced the capabilities of its microprocessors by developing and marketing sophisticated software, a variety of programming languages and "peripheral chips". In its 1977 Annual Report, Intel stated:

> "As microcomputers are used more widely, and in sophisticated multiprocessor and multitasking systems, more sophisticated software has been required. Intel continues to increase its rate of investment in software, which often is important in the customer's design decisions regarding which microcomputer products to use. A significant accomplishment for the year was the introduction of the RMX 80, a real-time multi-tasking executive for use with single board computers." (DX 12343, p. 22.)

Intel offers a number of languages for its microprocessors, including FORTRAN 77, Basic, PL/M, which is said to be similar in concept to IBM's PL/1, and PASCAL. (DX 14256; DX 14255.) And Intel provides "peripheral chips" to enable its microprocessors to control floppy disk drives, CRT displays and a variety of communications protocols. (DX 12344, p. 21; DX 14411.)

In addition to its microprocessor products, Intel offers what it describes as "the industry's most complete line of add-on memories for the IBM 370 series." (DX 12343, p. 23.)

Intel formed its Memory Systems Division in 1971 and began to manufacture computer memories which it sold to original equipment manufacturers. (DX 1275, p. 1; DX 12602, p. 12.) In the early 1970s Intel also began to manufacture IBM-compatible memories which it sold on an OEM basis to PCM marketers. (DX 12602, p. 12.) In 1975, Intel began to market its IBM-compatible memories directly to end-users and through leasing companies (DX 1275, p. 16; DX 3294A) and by 1978, manufactured and marketed memory for the IBM 370/125 through the 370/168 processors, as well as for IBM's 303X series. (DX 12343, p. 23; see DX 3294A; DX 3304; DX 11716; DX 12958; DX 12959.) Intel also manufactures memory for Digital Equipment computers. For the PDP 11 line, Intel offers products to expand memory to 4 million bytes; the company also offers memory for DEC's LSI-11 family. (DX 3303-A; DX 3305; DX 11719; DX 12960.)

Over the past several years Intel has also moved into new, high technology computer storage devices: charge coupled devices, bubble memory, semiconductor disk storage subsystems and data base processors.

(i) In 1976, Intel announced a CCD (charge-coupled device) replacement for disk and drum memories. (DX 3306-A.)

(ii) In 1979, Intel announced a million bit bubble memory chip which, according to Intel, opens "vast new opportunities to exploit the microcomputer". (DX 11721.) The bubble memory chip, according to Intel, permits 128 thousand bytes of memory to be utilized by a microcomputer. (Id.)

(iii) In 1979, Intel announced the Fast-3805 Semiconductor Disk Storage Subsystem. According to Intel, FAST-3805 utilizes semiconductor technology with far faster access times than disk technologies. Intel described the FAST-3805 as a random-access-memory-based device which emulates the IBM 3830/3350 and 2385/2305 disk subsystems and stated that it can triple disk traffic without requiring additonal channel or controller capacity. (DX 11720.) It was reported that "[t]he FAST-3805 can improve system performance without forcing users to upgrade their CPUs, add to main memory or add a fixed-head disk." (DX 14406.)

(iv) Early in 1979, Intel acquired MRI Systems Corp., which developed and markets the System 2000 data base management system for IBM, IBM-compatible, CDC and Univac computers. (Brueck, Tr. 22050-56; DX 14332, p. 5.) About a year later, Inte introduced its FAST-3805 Data Base Assist Processor. This processor utilizes Intel's Fast-3805 product to increase the speed of certain System 2000 functions. According to Intel, with this processor and MRI's data base management system "transaction throughput capacity can be improved by as much as 100 percent and with a 50 percent or better reduction in response time". (DX 12626.)

b. National Semiconductor Corporation. National Semiconductor was formed in 1967 (DX 12364, p. 7) and quickly became one of the leading manufacturers in the semiconductor industry. The company was formed with the goal of becoming a "leader in all aspects of the discrete and integrated circuit portions of the semiconductor industry". (Id.) By 1973, National had developed a variety of semiconductor component products and the company's next step was to "'vertically integrate' by adding carefully selected end-products which had a high semiconductor content". (Id.) In that period, National began what it later called "a seven year evolution--from a components supplier to being also a manufacturer of semiconductor-based computer systems." (DX 12365, p. 15; see DX 12364, p. 7.)

As the first step in that evolution, in 1973, National Semiconductor began to market point-of-sale terminal equipment, comparable to the equipment of other manufacturers, such as NCR and IBM. (See pp. 1058-60 above.) By 1974, National had developed a laser scanning system for use with point-of-sale systems. (DX 13682, p. 13.)

In the period 1974 to 1980, National added two significant computer product lines:

First, National began to manufacture IBM-compatible memory systems which were marketed by Itel and others to end users of IBM processors. (DX 12364, p. 17; see also DX 12366, p. 16.) By 1977, National was manufacturing memories for the 370/158 and 168 as well as "Memory 370" which could be attached to IBM computers ranging from the 370/135 to the 148. (DX 12364, p. 17.)

Second, National began to manufacture processors, "plug-compatible" with the IBM 370/148 and 158. This equipment, known as the "AS-4" and "AS-5" processors, was marketed by Itel. (Id.) National subsequently expanded this line and by 1979 had shipped over 300 processors compatible with the IBM 370/138, 148 and 158. (DX 12366, p. 16.)

By 1977, National Semiconductor had been "very successful" in its supermarket point-of-sale terminal business and considered itself a "leading outside supplier" of IBM-compatible memories. (DX 12364, p. 17.)

In its 1977 report to its shareholders, National Semiconductor management explained why computer products were "logical extensions" of National's semiconductor business:

> "National is a semiconductor company, and recognizes that its primary technical, manufacturing, and marketing skills have developed through the mass production of semiconductor components. The Company's strategic plans emphasize activities where these skills provide a competitive advantage.
>
> "There are many products which make extensive use of semiconductors, where the cost of semiconductors is a significant part of the total cost or where the technical application of semiconductors is critical to the product's success. Such products are logical extensions of National's capability." (Id., p. 14)

In 1978, National began marketing its memory products directly to end users. That marketing effort, and the expansion of National's product line, made National Semiconductor, in the words of its management, "a fully committed computer products company". (DX 12365, p. 3.) In its 1978 report to stockholders, National's management explained how that development had come about:

> "We have recognized for several years that a major opportunity for accelerating growth was to develop and manufacture digital systems in which semiconductors were the key to performance and success. These products accounted for approximately one-third of National's sales in 1978.
>
> "The major contributor to 1978's growth in sales and earnings was the large central processing units manufactured by our Computer Products Group. These machines are fully compatible with IBM 370 models 148 and 158 computers. The 100th system was shipped during the fourth quarter, 14 months after shipments started.
>
> "National now has systems products throughout the entire computer range, including microcomputers, memories for mini and large computers, as well as full-scale central processors. Most of these products utilize well-established software, which allows us to focus on equipment, where semiconductors play the key roles.
>
> "Early in May, National announced the System/400, a complete high-level minicomputer which utilizes IBM 370 operating systems and application software. This allows customers to use existing IBM software at a substantial savings in equipment cost. Initial deliveries are expected in calendar 1979.
>
> "Also in May, we initiated a direct marketing program to supplement the sales effort on our IBM-compatible add-on memories. For field service, we utilize the established structure of our point-of-sale systems service organization.
>
> "With the development of these advanced new products and the establishment of a direct marketing and service organization, National has truly become a fully committed computer products company." (Id.)

As the 1970s drew to a close, there were several significant developments in National Semiconductor's business.

First, the company reported advances in "bubble" memories which "are expected to replace disk, drum and tape memories in future computers". (DX 12366, p. 7.)

Second, National began offering directly to end users memory products plug-compatible with DEC processors. (DX 14263, p. 56.)

Third, in 1979, National Semiconductor acquired Itel's computer sales, service and support operations and renamed the organization National Advanced Systems: "On October 1, we committed ourselves to the compatible computer industry in an even bigger way. . . . National Advanced Systems will market a complete line of medium-to-large scale IBM-compatible computer products, including current and future systems from National and other computer and peripheral manufacturers." (DX 11827.) National Advanced Systems has since announced the AS/3000 Series, equivalent to the IBM 4341 processor and the 370/158-3, the AS/5000 Series, equivalent to the IBM 3031 processor, and the AS/7000 Series, equivalent to the upper end of the IBM 303X Series. (DX 14117.) The three models of the AS/7000 Series are manufactured in Japan by Hitachi, which had also been marketing these larger IBM-compatible processors through Itel. (DX 13751; see Withington, Tr. 112944-45.)

Over the course of the 1970s, National Semiconductor's growth was exceptional. From revenues of $11 million in 1968, the company grew to $213 million in its fiscal year 1974 (ending on May 31). (DX 13682, p. 25.) By fiscal 1977, its revenues were $387 million. By fiscal 1979, the company's revenues were $719 million, placing it 353rd in the Fortune 500 listing of the largest U.S. industrial companies. (DX 12366, p. 17; DX 13946, p. 290.) The company's revenues for fiscal 1980 were reported to be $980 million, a 36.2 percent increase over 1979. (DX 14264.)

72. Communications Firms. When all computer equipment that was part of general purpose computer systems was located in a single room, data communications--across distances--played little, if any, role in computer systems. (Akers, Tr. 96648-50; DX 3705, p. 127.) But even in the 1950s, customers, at least advanced customers, were seeking methods of configuring computer systems that were not bounded by a computer room, systems in which, for example, input and output and even processing and storage could be performed at remote locations. The military's SAGE system of the 1950s (discussed above at pp. 68-78; see Crago, Tr. 85975-76) and the IBM/American Airlines SABRE airlines reservation system (discussed above at pp. 138-39 and below at pp. 1380-88; see also Welke, Tr. 17314; Case, Tr. 73278-79; O'Neill, Tr. 76005-08) are examples of these early efforts at computer systems made up of equipment dispersed in far-flung geographic locations.

By the 1960s, and particularly by the 1970s, such systems became commonplace (J. Jones, Tr. 79319-21, 79989-90; see also R. Bloch, Tr. 7842; Binger, Tr. 4533-34; Withington, Tr. 56983-84; Akers, Tr. 96648-50) and computer users routinely configured their computer systems with substantial and growing amounts of geographically dispersed equipment of all kinds. Thus:

(i) Akers testified that the increasing capability of hardware and software and the use of data communications capabilities have given rise to

"the ability for an individual not to have to pick up his work and take it to the computer room, but rather to sit where he or she works and input that work, then have the computer system do the work and output it back to that individual, and not just one at a time, but many at the same time.

" . . . [T]he flow of information from individuals who are inputting the work into a processor, perhaps another processor, multiple processors, physically distributed across that enterprise [and] . . . stored at various places throughout that enterprise and that system, and finally giving the answer to the individual that after all the whole thing is for anyway, is the way in which today's enterprises in American industry use computers.

"So it has changed from the early days . . . from a rudimentary approach to doing the job, to doing a job for the individual wherever he or she physically resides." (Tr. 96649-50.)

He stated that computer systems are the "aggregation" of all the "hardware and software [products] that perform the work", including terminal equipment and communications products, and suggested the airlines' use of such systems as an illustration.

"The airline utilizes terminals, communications equipment, together with processors and storage, both magnetic tape and disk files, and printers and modems, and certainly other products to perform that work.

"So the aggregation of all those products, hardware and software that perform the work has always been the computer system and is the computer system today." (Tr. 96657.)

(ii) The Federal Communications Commission found in its recent Computer Inquiry II decision (Docket No. 20828, 5/2/80):

"[S]ignificant advances in computer hardware and software have been made since [1970]. In particular, dramatic advances in large-scale integrated circuitry and microprocessor technology have permitted fabrication of minicomputers, micro-computers, and other special purpose devices, which are capable of duplicating many of the data-manipulative capabilities which were previously available only at centralized locations housing large scale general-purpose computers. With this new technology, users now find it cost-beneficial to remove some of the computing power from a centralized computer location. The phenomenon of distributed processing allows computers and terminals to perform both data processing and communications control applications within the network and at the customer's premises." (DX 12702, pp. 8-9.)

(iii) In 1974 Withington predicted that in the decade to follow, approximately 70% of the data of large computer systems users would be "keyed or otherwise captured at remote terminals". (Tr. 57696.)

(iv) McGrew of Union Carbide testified that in 1970 there was "not very much" communications activity in connection with the operation of the company's data processing system. (Tr. 76412-13.) By 1978, however, Union Carbide's data processing system "coud [sic] not function" "[w]ithout [its] communications". (Tr. 77212.) During the first half of the 1970s, "there was more communications coming along all the time". (Tr. 76413-14.) As Union Carbide's system grew, "it was necessary to add a lot of remote terminals . . . . So the communications element became quite large, much larger." (Id.)

(v) John Jones of Southern Railway explained how Southern had taken a "distributed approach . . . which results in taking processing away from the central site, the central machines, and moving it out to the distributed processors". (Tr. 79989.) He testified that this would "have a direct effect on the size and the growth in size of the central processors". (Id.) In fact, while many other railroads of comparable size were using System/370 Model 168 processors, Southern Railway was using smaller Model 158 processors and used the money it thereby saved to buy "Data General equipment and [put] the processing on that equipment out in the field". (J. Jones, Tr. 79989-90.)

As computer systems, particularly distributed or decentralized systems and computer networks have increasingly incorporated equipment and software that enable the systems to operate across distances, "the computer industry and the communications industry", as the FCC has found, "are becoming more and more interwoven". (DX 12702, p. 42; see pp. 1223-24 below.)

The result has been that firms originally in the communications business are taking even more aggressive roles in the computer industry.

a. AT&T. AT&T is, of course, one of the world's largest corporations and a leader in communications technologies. Its reported revenues for 1979 were $46.18 billion. (DX 14445, p. 1.)

AT&T has been a major participant in the computer industry and a major competitor of IBM for many years (see above, pp. 174-80, 736-49), but the scope of that competition increased in the 1970s. In its current product planning IBM keeps "as careful an eye on AT&T as [on] any individual enterprise that competes with the IBM Company". (Akers, Tr. 97038.) As AT&T itself has recognized, communications and data processing technology are rapidly converging. (See DX 12275, p. 7.) For example, in its response to the Federal Communications Commission's (FCC) rulemaking inquiry into the relationship between data processing and communications (Computer Inquiry II) in 1975, AT&T stressed that data processing and communications technology have become increasingly intertwined and that AT&T's ability to use data processing technology is "essential" to its provision of communications service and to the management and operation of its facilities. (See DX 12274, p. 20; see also DX 12275, pp. 13-14, 18.)

In the 1970s AT&T introduced a number of products and services that compete with a wide range of computer offerings, including IBM's. For example:

(i) The Dataspeed 40 Terminals. Western Electric Corporation's Teletype subsidiary has, of course, been a prime competitor of IBM in computer terminal equipment for many years. (Akers, Tr. 96834; see also PX 2125, p. 121.) In 1973, AT&T introduced the Dataspeed 40 line of terminals. (DX 14099 ; see also DX 11162.) In 1975, AT&T announced new models of the Dataspeed 40 (later called 40/4) terminal, as a direct replacement for the IBM 3270 terminal. In 1977, the Dataspeed 40/4 was further enhanced. (DX 14100; DX 13098; see also DX 12721.) In marketing to the Bell System operating companies, IBM has faced substantial competition from the Dataspeed 40/4. For example, in January 1978, New York Telephone selected 7,000 Dataspeed 40/4s, 20 Comten 3650 Communications Processors and 16 CDC Cyber 1000 Communication Switching Systems for AT&T's "Bell Administrative Network Communication System" (BANCS). 700 installed IBM 3277 terminals were to be displaced. IBM "no bid" because, according to IBM's internal reporting, "AT&T wants to use their own product"; the customer "did not see IBM as an appropriate solution" because the customer "sees IBM as a competitor". (PX 6467, Vol. 5, January, p. 14.) IBM's loss of this business represented a potential of about $1.2 million per month in rentals. (Id.)

Similarly, in March 1978, AT&T's Long Lines Division selected 4,000 Dataspeed 40/4s over IBM 3270 products. According to IBM's internal report of the procurement, the Dataspeed was selected because "AT&T wants to use their own product" and because the customer "sees IBM as a competitor". In this situation, the loss to IBM was approximately $650,000 per month in rentals. (PX 6467, Vol. 5, March, p. 14.) As Akers testified, the Dataspeed 40 is "a powerful and very successful product line" (Tr. 96834) that is "extremely successful in the marketplace" (Tr. 97045) and "competes with a variety of [IBM] terminals . . . but it probably competes with the 3270 line more often than any other". (Tr. 96834.) "[T]ens of thousands, hundreds of thousands" of monthly rental dollars have been lost by IBM "head for head, one for one" to the Dataspeed 40. (Tr. 97044-45.)

(ii) Dimension Private Branch Exchange (PBX). Early in 1975, AT&T introduced the first of a family of PBXs known as the Dimension PBX. As AT&T described the Dimension PBX in its 1974 Annual Report, it

> "uses solid-state technology and a miniaturized computer which provide the flexibility to add features in the future to meet

the changing needs of customers." (DX 12271, p. 16.) In recent years, AT&T has expanded the features offered with its Dimension systems. For example, in 1976 the newest Dimension system offered more than 150 features, and AT&T began offering the System to meet the needs of the retail and hotel/motel industries. (DX 12273, p. 14.) By 1980, Electronic News reported that the Dimension 2000 provided automatic wake-up service, room status, inventory reports and itemized telephone call billing for hotels. (DX 13107.) In these applications, AT&T routinely met with competition from IBM and other computer manufacturers. For example, Akers testified that AT&T's Dimension 200 and 400 models were offered to hotels and motels for applications that could be performed by IBM's General Systems Division systems, System/370, 4300 or 3000 series products. (Akers, Tr. 97040.) At the Americana Hotel in New York City an IBM System/3 is used to perform its reservation work and at the Western International hotel chain the reservations applications is performed by an IBM System/370 Model 195. (See below, p. 1396.)

In addition, Electronic News recently reported that AT&T's Dimension has been expanded to perform "energy-management functions" and has been used to perform that application at the McCormick Inn in Chicago. (DX 13107.) The report notes that the user

> "had looked at comparable energy management systems from such computer makers as IBM and Honeywell but preferred the Dimension's integrated telephone and energy management operation." (Id.)

(iii) Transaction Network Service (TNS). In 1976 AT&T introduced TNS, which "was developed to handle large volumes of business transactions that call for short inquiries and responses". (DX 12273, pp. 13-14.) Applications include credit authorization and check verification. (Id.) According to reports prepared by the Commercial Analysis department of IBM's Data Processing Division, TNS includes terminals and message transmission and switching software. The report also stated that TNS could be used for Electronic Funds Transfer System (EFTS), reservation systems, inventory control and quotation services, as well as credit authorization and check verification (DX 13251), applications which are commonly performed by IBM's computer systems. (See pp. 1355-60, 1380-95, 1409-12 below.)

(iv) Advanced Communications Service (ACS). In July 1978, AT&T filed a petition asking the FCC to tariff AT&T's proposed Advanced Communications Service. (DX 12275, p. 10.) According to a *Datamation* report, through ACS, AT&T would provide, with the use of its own computer hardware and software, unified network control of customers' processors and remote terminals or storage devices. (DX 13101.) According to the report, both communications and data processing functions would be performed by ACS. The report also pointed out that, as planned, ACS would offer program and data storage and a variety of other computer services on a shared basis. (Id.) Within IBM, the Data Processing Division's Commercial Analysis department concluded that ACS "can perform all or most of the functions performed by current distributed data processing products" and that "the intent [of ACS] . . . is to enlighten the many dumb terminals now installed by putting intelligence and storage into the network". (DX 13252, p. 8.) Akers testified that, when available, ACS, "will compete directly with [IBM's] products and services". (Tr. 97037.)

(v) Software. AT&T also licenses computer software. As an advertisement which appeared in the February 1978 Datamation states:

> "[A]s one of the world's largest computer users, the Bell System has developed a lot of software for its own use. For data management, statistical analysis, practically anything done with computer. A limited amount of this software has been made available for licensing . . . [including]: The UNIX system . . . a multi-programmed, time-share operating system for the DEC PDP 11/40-45-70 minicomputers. It has features seldom found even in larger systems, including over 100 sub-systems and utilities." (DX 11165.)

Other software products marketed by AT&T include a computer management system and a text-editing system. (Id.)

(vi) ESS and Other Switching Systems. In the 1970s IBM continued to offer IBM computer equipment to the Bell System operating companies in competition with Western Electric computer hardware products. For example, in the early 1970s, as AT&T continued its changeover to its Electronic Switching System (ESS) which it had begun in the mid-1960s (DX 12271, p. 15),* IBM was bidding System/360, Series/1 and System/7 products, among others, against ESS at Bell operating companies. (Tr. 97036-37.)

IBM has marketed the System/7 in competition with the Bell Labs "TDR System" for traffic data collection applications at Bell telephone companies. (DX 12426.) IBM has also marketed the System/7 and Series/1 for computerized Directory Assistance Systems (DX 9402,

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* The ESS is a stored program computer which performs many applications, including customer billing and accounting, for AT&T. (See pp. 738-41 above.)

p. 399) and duplexed Series/1 processors to perform Computerized Electronic Billing System (CEBS) applications in competition with Bell System products, such as LAMAC, ETS--which uses ESS processors--and BDT, which perform the same application. (DX 9402, pp. 401-02.)* System/7 has also been marketed by IBM to the Bell System for toll ticketing and traffic and trouble analysis applications (DX 12424) and for Automatic Message Accounting (AMA). (DX 12424; DX 12427; DX 12428; see also DX 9402, pp. 399-406, 411-12.)

b. Northern Telecom, Limited. Northern Telecom, Limited is a Canadian company with total corporate revenues in 1979 of $1.9 billion. It is "the principal supplier of telecommunications equipment in Canada and the second largest in North America". In 1979, roughly 40 percent of Northern Telecom's revenues came from operations in the United States. (DX 13894, pp. B, 1, 2.)

At a relatively early time, the management of Northern Telecom recognized the progressive merging of data processing and communications capabilities and technologies: In 1975, Northern Telecom introduced a digital switching system and in 1976 announced its "Digital World" line of "telecommunications systems based on digital technology". (DX 14443, pp. 5, 13.) Digital World systems include computers. According to Northern Telecom:

> "The basic technique used in digital telecommunications systems is identical to that used in most computers: infor-

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* A CEBS collects, translates and assembles automatic message accounting entries for all calls requiring billing on a particular switch. (Id.)

mation is transformed into numerical codes and represented by electrical pulses. Each system is programmed to identify, sort and compare electrical pulses and to make decisions as to what to do with them. This decision-making process constitutes the intelligence of an electronic system. It is essential to digital telecommunications equipment, such as Northern Telecom's Digital Multiplex System (DMS) family of products, and to computers." (DX 14443, p. 13.)

In 1978, Northern Telecom completed several significant acquisitions in the United States which, coupled with its telecommunications expertise, made the company a significant competitor in the EDP industry, ranked 20 in data processing revenues by Datamation in 1979. (DX 13945, p. 7.)

First, the company acquired Data 100 for approximately $163 million in cash, and then acquired Sycor, Inc. for approximately 3.1 million shares of stock worth approximately $84 million and Danray, Inc., for approximately $25 million in cash. (DX 14443, p. 37.) In addition, as of 1979, Northern Telecom owned a 21.9 percent interest in Intersil, a manufacturer of integrated circuits and IBM-compatible memory systems. (DX 13395, pp. 2, 5; DX 13894, p. 41.)

In 1978, Northern Telecom created Northern Telecom Systems Corporation (NTSC) to manage its "electronic office equipment business"; and Data 100 and Sycor were placed under NTSC management. (DX 14443, p. 6.) For 1979, Northern Telecom reported NTSC's revenues as $349.8 million, or 18.4 percent of total corporate sales. (DX 13894, p. 2.)

Northern Telecom has repeatedly expressed its strategy to utilize digital technology in its communications products and to create what it refers to as its "Intelligent Universe". In 1978, Northern Telecom articulated the elements of that strategy, which has been spawned by "the confluence of computers and telecommunications" (DX 14443, p. 12.) After discussing its acquisitions of Sycor and Data 100 (see below), Northern Telecom stated:

> "Their terminal systems provide access to central computers from remote sites through private networks or through telephone lines as well as providing on-site computing capabilities. They are a natural and logical extension of our traditional telecommunications business.
>
> "However, our interest in these companies is not solely the development of a significant position in the data distribution industry. They are an essential element in the creation of a corporation that will be a leader in the clearly identified trend of a coming together of the telecommunications and data processing technologies. The combined technologies will be the telecommunications industry of the 1980s and beyond.
>
> "This trend has been accelerating since the early 1970s. At its root is the fact that the telecommunications and computer-data-processing industries use the same basic technologies in the design of their products: software and integrated circuits.
>
> "We believe the future of the telecommunications industry will fall to those companies which can provide total communications network planning and production. Our historical strength in telecommunications and our new strength in electronic office equipment will give us the same market advantage in the so-called office-of-the-future as we hold today in digital telecommunications." (Id., pp. 6-7.)

In 1978, Northern Telecom also reported that since the late 1960s it had recognized that "the convergence of computers and telecommunications would take place in two distinct but related areas: distributed data processing and computer communications". According to Northern Telecom, distributed processing had "increased dramatically in the last five years" and had become the "fastest-growing segment of the industry". (DX 14443, p. 14.)

As reported above, it was those trends which motivated

Northern Telecom to acquire Danray, Data 100 and Sycor:

Danray manufactures the Auxiliary Data Exchange which permits users to connect computers, terminals, word-processing machines and "other information generating equipment to their own internal telephone systems". (DX 14443, p. 16.)

Data 100 was formed in 1968. Its initial products were remote batch terminals. (DX 3897, p. 4.) From that time until its acquisition by Northern Telecom, Data 100 created a family of terminals and processors which, according to Data 100, could be used for "remote job entry, data entry, remote or local file management, stand-alone processing, or any combination of these". (DX 11675; see also DX 11674.) The company's revenues, $3.8 million in 1971 and $13 million in 1972, reached $42 million in 1973, and grew to $138 million by 1977. (DX 11057, p. 18; DX 13557, p. 19; DX 14248.) Data 100's product offerings have been described by Northern Telecom as follows:

> "Data 100 terminal systems produced by Northern Telecom are multifunction systems which can do much of the work previously done only by mainframe computers. The Model 85 remote information system introduced in 1978, for example, maintains local information files in addition to transmitting and receiving information from a central computer. It is used for payroll, inventory control, production control, general ledgers and other tasks usually assigned to a mainframe." (DX 14443, p. 16.)

Sycor was formed in 1967 and began shipment of its first products, terminals, in 1969. (DX 5923, pp. 3, 5.) By 1977, Sycor had expanded its offerings to include an array of products for distributed data processing. For example, Sycor advertised its 405 and 445 "distributed processing systems", connected by its "Sycorlink" networking feature, as permitting the distribution of processing power which "can be tailored to handle the processing tasks of individual departments" as well as giving "any department the power to access the files and peripherals of every other system in the network." (DX 11986; see also DX 11985; DX 11984.) Sycor enjoyed rapid corporate growth in the 1970s with revenues growing to approximately $77 million by 1977. (DX 14282, p. 1.) Sycor's products have been described by Northern Telecom in this way:

> "Northern Telecom's Sycor intelligent terminal systems enter information and process data at sites remote from a central computer. One of Northern Telecom's most sophisticated terminal systems, the Sycor 445 distributed data processing system, is equipped with a central processing unit and up to eight individual work stations. These work stations concurrently and independently perform a variety of different tasks such as data entry, data communications and data processing. An innovative software package introduced in 1977, called SYCORLINK, enables the Sycor 445 and other Sycor distributed data processing systems to communicate with each other and to share printing devices and information stored on magnetic disks." (DX 14443, p. 16.)

Northern Telecom has apparently realized that the same forces that have given rise to its corporate strategy--including the Data 100 and Sycor acquisitions--have intensified competition among traditional communications and data processing companies. In fact, Northern Telecom has reported that the commonality of technologies used in communications and digital data processing "has attracted new competitors from around the world in the electronics and computer fields. These companies, often major factors in their original markets, are developing, or have developed, products to compete in one or more segments of the [communications] market. They are complemented, of course, by our traditional telecommunications competitors from the U.S., Europe and Japan." (DX 14443, p. 6.)

c. <u>FCC Computer Inquiry II.</u> Perhaps the most significant development of the 1970s, in the context of the role of AT&T and other large communications firms in the EDP industry, has been the FCC's recent (May 1980) decision in Computer Inquiry II (Docket No. 20828). (DX 12702.) In that decision, the FCC adopted a policy of regulating only "basic transmission services", defined as "limited to the . . . offering of transmission capacity for the movement of information". (DX 12702, p. 38.) The FCC expressly determined that it was not in the public interest for it to regulate "enhanced services", which it defined as

> "any offering over the telecommunications network which is more than a basic transmission service. In an enhanced service, for example, computer processing applications are used to act on the context, code, protocol, and other aspects of the subscriber's information." (<u>Id.</u>, pp. 39-40.)

The FCC reasoned that:

> "We believe that our adoption of a differentiation between basic and enhanced services best furthers the public interest because it comports with the actual development of this dynamic industry. As the market applications of computer technology increase, communications capacity has become the necessary link allowing the technology to function more efficiently and more productively. Transmission networks have benefitted from some of the productive breakthroughs which this relatively new field has made possible. As a result, the computer industry and the communications industry are becoming more and more interwoven. We believe, and the record shows, that this trend will become even more pronounced in the future. As it does, an increasing number of enhanced services will be developed to meet the need of the marketplace. Thus, the pressure on a set of administrative rules which fail to recognize the growth in operational sophistication demanded by our nation's economy will be inexorable.
>
> "The distinction we adopt today recognizes that development and indeed should encourage its continuation." (<u>Id.</u>, p. 42.)

Similarly, the FCC ruled that it would no longer regulate any customer premises equipment (CPE). (Id., pp. 5, 124.) The FCC declined to distinguish among CPE used for different functions in determining tariffs.

> "[T]he rapid pace of technological evolution would quickly render obsolete any attempt to draw distinctions among customer-premises equipment based on processing functions." (Id., pp. 56-57.)

In its ruling, the FCC stated:

> "We have concluded that CPE should not be classified as to its communications or data processing characteristics and that no classification scheme should be adopted. Implicit in this is the fact that no demarcation can be drawn for differentiating CPE for tariff purposes." (Id., p. 68, ¶ 157.)

Further, the Commission made explicit its conclusion, based upon its reading of the 1956 AT&T Consent Decree and its jurisdictional authority, that AT&T was not foreclosed from providing either unregulated customer premises equipment or enhanced services. (Id., pp. 117-23.) Thus, AT&T in the FCC's view, is now free to compete on an unregulated basis in all areas of the electronic data processing industry.

Even before the FCC decision, IBM was concerned about future AT&T competition. John Akers, IBM Vice President and Group Executive, Data Processing Marketing group, testified that he considers AT&T "one of the key challenges the IBM Company faces in the future." (Tr. 97046.)

The record shows that AT&T is not alone and AT&T itself recognizes this fact.

In its Petition for Reconsideration to the FCC filed on June 12, 1980, in Computer Inquiry II, AT&T stated:

"The other vendors in the marketplace already have recognized the vital importance of providing total systems that integrate the preparation, transmission and reception of messages. . . . IBM, Xerox, Exxon, Northern Telecom, Fujitsu, Nippon Electric, Siemens, and other domestic and foreign vendors of data processing systems, office equipment, computer services, word processing systems, or communications services and equipment . . . are extending their product lines into related areas of information management . . . through acquisition, joint ventures, or internal development . . . to offer total systems that integrate transmission facilities with [customer premises equipment] to form innovative total system designs. . . ." (DX 13662, pp. 21, 28.)

For example, according to AT&T:

(i) Xerox has stated its intention to undertake internal development programs, has acquired five companies and has entered into joint ventures with three others to develop and market a wide range of data processing and communications products and services;

(ii) IBM has a joint venture (SBS) for satellite communications;

(iii) Exxon has acquired at least eleven companies and launched a variety of product and service programs in communications;

(iv) domestic communications companies, such as Continental Telephone, have moved into satellite communications, switching networks and system integration; and

(v) foreign companies, including Siemens, Fujitsu and Nippon Electric have historically had or expanded into capabilities in both data processing products and an array of communications offerings. (DX 13662, pp. 22-26.)

73. Other Competitors

a. Software Companies. As detailed earlier (see pp. 851-65 above), software companies, which began to emerge in the 1950s, entered the industry in large numbers in the 1960s. Those companies provided software and technical assistance to both hardware manufacturers and users and they offered software as alternatives to similar offerings by hardware manufacturers and, in many cases, as alternatives to hardware marketed by those manufacturers. (See pp. 859-61.)

Welke testified that in 1975 there were approximately 1,000 independent firms offering "slightly more" than 3,000 software products, as well as contract programming services, for total revenues of approximately $1.3 billion. (See Tr. 17167-68, 17176-81, 17400.)

The software products available in the marketplace covered a broad range of uses. For example:

(i) The Computer Software Company (TCSC) offers a product called EDOS, which is claimed to enhance IBM's Disk Operating System for 360 and 370. (See Enfield, Tr. 20143-44.) Early in the marketing of EDOS, which was announced in 1972, TCSC encouraged leasing companies "to utilize EDOS as a means of enhancing or extending their system 360 portfolio". (Enfield, Tr. 20167, 20847.) According to Enfield, "EDOS had a tendency to improve the performance of those 360 systems, with that improved performance, they were capable of installing or marketing the software in connection with the marketing or replacing of the hardware." (Enfield, Tr. 20169.) Using this strategy, TCSC was able to increase the number of installation of EDOS from 25 to 30 in 1973 to approximately 350 at the time of Enfield's testimony in 1976.* (Enfield, Tr. 20165-66.)

(ii) Software Pursuits, Inc. markets an operating system for IBM 360 and 370 computers called DOS/MVT as a replacement for IBM's DOS and DOS/VS operating systems. According to Software Pursuits, DOS/MVT "provides more features and capability than any similar product on the market, and it provides enhanced throughput. The net result for you, the user, is reduced cost." (DX 14279 .)

(iii) Software Design, Inc. (SDI) markets "GRASP", a progr product which SDI advertises can "increase system capacity" an can result in "[m]uch smaller core and disk requirements". (D 6710, pp. 2, 7; DX 6711.)

(iv) Informatics markets a product called SHRINK, which i a file compression system that is claimed to solve "the data storage problem by compressing your present large disk and tap files--by 80% of their original size." This results in "reduced need for disk spindles, tape drives, disks and tapes." (DX 11706) Other companies, such as Computer Action, Inc., Applied Data Research and Electronic Data

* The Computer Software Company was acquired by Nixdorf Computer in 1980.

Preparation Corp., also market data compression and data management products that reduce disk storage requirements. (See DX 1072, pp. 8, 23; DX 6343, p. 16; DX 14237.)

The discussion of the companies that follows illustrates the variety of software products available to users and the degree to which many software vendors are increasingly integrating the businesses of developing and marketing software, computer services and hardware.

(i) Cincom Systems, Inc. Cincom Systems, Inc. was formed in October of 1968 with an initial capitalization of between $500 and $600. (DX 3920, pp. 8, 31.) Cincom's 1979 data processing revenues were reported to be $31 million. (DX 13945, p. 9.)

Cincom's major offering since the time of its formation has been the TOTAL data base management system (Welke, Tr. 17206), which offers a variety of data base functions. (DX 12771, pp. 2-3; see DX 12644, pp. 5-6.) TOTAL was written initially to operate on IBM computers and today it is implemented to operate on IBM's System/360, /370, System/3 and System/34 computers. (DX 2642-A; DX 12698; DX 12771, p. 2.) IBM has, over time, offered a variety of software alternatives to TOTAL, including IMS, DL/1 and DBOMP. (DX 3920, pp. 15-16; see also Akers, Tr. 96711; Brueck, Tr. 22076-77.)

According to Cincom, TOTAL "imposes the lowest overhead of any full facility DBMS available today. Its powerful design minimizes I/O memory requirements and disk space. This gives you all the benefits of the Total Approach while minimizing your hardware investment." (DX 12698.) According to Cincom, among the benefits of TOTAL are that it "reduces core requirements and increases effective disk storage capacity and performance". (DX 12772, p. 12.)

In addition to IBM computers, Cincom advertises, and it has been reported, that TOTAL runs on computers manufactured by: DEC, Perkin-Elmer, Prime, Honeywell, Univac, CDC, NCR, Varian, International Computers, Ltd., Harris and Modcomp. (DX 2642-A; DX 11301; DX 12644, pp. 5-6; DX 13141; DX 12923; DX 11564.) It has also been reported that "data bases implemented under TOTAL on one computer are fully compatible and portable to any of the other machines." (DX 12644, p. 6; see DX 12698; DX 12639.)*

Brueck testified in 1976 that "[c]ertainly CINCOM has been very successful selling their product TOTAL" (Tr. 22031-32) and Withington characterized TOTAL as "widely used." (Withington, Tr. 57661-62.) In January 1975 Cincom was advertising that TOTAL, with 800 installations, "is said to be the most widely and successfully used DBMS package in the world." (DX 11298.) In February 1979, according to Cincom, there were over 2500 installations of TOTAL worldwide. (DX 11301.)

Cincom markets TOTAL as an alternative to a variety of dat base management system offerings not only from manufacturers but

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* Withington testified that the portability of TOTAL to different vendors' computers is "one of the factors that is in its favor should one in the future wish to change vendors." (Tr. 57666-67.)

also from other independent software vendors. For example:

(a) The trade press reported that "[f]or systems software vendors, the largest growth market is in the area of DBMS. Informatics' Mark IV, Cincom's TOTAL, Cullinane's IDMS, MRI's System 2000, Software AG's ADABAS count thousands among their users." (DX 12641, p. 90.)

(b) Brueck testified that his company's data base management system, System/2000, faced competition from IDMS marketed by Cullinane, ADABAS marketed by Software A.G., CCA 204 marketed by Computer Corporation of America, RAMIS marketed by Mathematica and DATACOMM DB/DC marketed by Computer Information Management. (Tr. 22076-77; see Goetz, Tr. 17668-69.)

(c) A November 1979 survey of data base management systems described the data base software offerings of 18 software companies, which operate on a broad spectrum of computer systems, including, for example, minicomputers manufactured by DEC, Systems Engineering Laboratories, BTI Systems, Inc., Data General, Modcomp, Perkin-Elmer, Basic Four, and Wang. In addition, the data base offerings of some of the manufacturers were analyzed, including those from Data General, DEC, Hewlett-Packard, Honeywell, Prime, Tandem and Texas Instruments. (DX 12644, pp. 5-9.)

(d) Data services companies have also developed data base management systems, which they offer with their data services. These include NOMAD marketed by National CSS, MANAGE marketed by Computer Sciences and MAGNUM marketed by Tymshare. (DX 12641, p. 90.)

Recently, companies have begun offering data base management software for implementation on "microcomputers". For example, Micro Data Base Systems, Inc. reportedly offers its MDBS data base management system for both the Zilog Z80 and the Intel 8080 microcomputers. (DX 12644, pp. 7-8.) International Data Base Systems, Inc. offers its Micro-Seed DBMS for the same microcomputers, as well as for the Intel 8085. According to International Data Base Systems, Inc., Micro-Seed is "a compatible subset" of its SEED data base offering. SEED has been implemented on IBM's 360, 370, 303X and 4300 Series computers, as well as on computers manufactured by DEC, CDC, Modcomp and Hewlett-Packard. (DX 13611.)

(ii) System Development Corporation. System Development Corporation (SDC) was organized as a not-for-profit corporation in 1956 "to support the Air Force with system training and computer program development, installation and maintenance for the SAGE Continental Air Defense System." (DX 12385, p. 3.) According to SDC, "[s]oon it became evident that the demands for the first giant information system, operating in real time, were unlocking the door to a dynamic new technology." In 1956, SDC was "chartered . . . to open that door to its widest reaches." (DX 12387, p. 5.) Between 1965 and 1969 SDC continued to develop information systems for the government. In 1969, however, SDC decided to "seek additional outlets for its technological strengths in the burgeoning market for industrial and commercial automation" and converted to a for-profit corporation "free to compete in all sectors." (Id.)

Since 1969, SDC has expanded into new areas and today offers a variety of contract services, programming and data services for a wide variety of users. In 1974 SDC described its evolution as follows:

> "In the past 17 years, we have evolved from a supplier of computer programs and training systems designed primarily for federal government customers to a total systems company providing a select range of computer-based services and products for industry as well as all levels of government." (DX 12385, p. 6.)

SDC offers "turnkey" systems, utilizing its own software and hardware it purchases from manufacturers. For example:

(a) SDC offers the TEXT II "newspaper automation system", which employs a network of "minicomputers" and SDC software to provide "a complete system capability for automated entry, editing and composition of news and advertising copy" as well as "automated billing, accounts receivable, cash posting and management reports". (DX 12385, p. 4; DX 12388, p. 2; DX 10653, pp. 3-4.)* In 1976, SDC noted that the [AN/FS]Q-7 computer, which was the "heart of the Sage air defense system", "required eighteen large trucks, filled an entire building, contained 60,000 vacuum tubes, and consumed the equivalent of

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* In 1975 IBM, bidding two 370/135s and 35 3270 displays, lost to SDC's TEXT II system based on "Hewlett-Packard 2100 minisystems" at the Des Moines Register and Tribune. (PX 6467, Vol. 2, August, p. 15.)

one-twelfth the electric power of the City of Santa Monica." The computer for the TEXT II System, however, "is housed in a single file cabinet, stores its logic on one circuit board, requires the power of eight light bulbs, and is six times faster than the Q-7." (DX 12387, p. 6.)

(b) SDC also markets an on-line retail banking system, consisting of a "minicomputer" and SDC software, linked to terminals for "teller inquiry, instant signature verification, on-line account information and automatic teller machines." (DX 12388, p. 2.)

In addition to such turnkey offerings, throughout the 1970s SDC continued its involvement in the development of "Command, Control, Communications and Intelligence Systems" such as those it first developed during the SAGE Project. For example, SDC has developed and installed an "integrated satellite data processing system" in the Cheyenne Mountain complex. (DX 12385, p. 6.) SDC also designed the "Emergency Command Control Communications System" for the Los Angeles Police Department (DX 12390, p. 6), "an automated police dispatching system". (DX 12389, p. 3.)

SDC also provides a variety of services offerings, both through its own computer facilities and by developing or managing users' systems. In 1979, SDC reported that this was one of the "fastest growing areas of the Corporation" and that its "services business has doubled in volume over the last three years." (DX 12390, p. 6.) These services are divided by SDC into two categories: support services and transaction services.

Through its support services offerings SDC operates its customers' computing facilities and provides other technical and operations support. (Id.) SDC has developed information systems for many users, including municipalities and hospitals, as well as providing facilities management services for a variety of users. (DX 10650, p. 4; DX 7191, pp. 2-3; DX 10651, pp. 6, 10.)

SDC's transaction services "enable many customers to access SDC's special information management systems, paying for service on a 'per transaction' basis." (DX 12390, p. 6.) SDC provides a variety of services through its own computer facilities: a Claims Administration System which provides computerized processing of medical and dental claims for corporations and insurance companies (Id., p. 7; DX 12389, p. 4); several automated services for banking applications "including investment and dividend reinvestment, account records maintenance, and processing of time deposits and mortgage loans" (DX 12388, p. 2; DX 12385, p. 2); and "Search Services" which provide on-line information bibliographic retrieval from SDC's "vast information store in science, technology, engineering, patents and commerce". (DX 12388, p. 2; DX 12385, p. 5.)

In addition to its software and services offerings, over the past several years, SDC has built upon its experience in fabricating hardware subassemblies and moved toward the manufacture of hardware products. In 1977, SDC explained that "the systems that SDC delivers are often interlocking combinations of hardware and software." (DX 12388, p. 6.) SDC stated that

> "SDC's hardware involvement is destined to grow. Industry-wide developments in minicomputer and micro-computer technology, customer preferences and recent developments in SDC's own R&D program combine to make this inevitable." (Id.)

In 1978, SDC reported that

> "SDC's move toward hardware is backed by a major research and development effort. More than half the company's research and development budget is devoted to developing proprietary hardware technology for early delivery to the marketplace. If our expectations are met, as we believe they will be, this technology can represent a major breakthrough in information processing." (DX 12389, p. 5.)

That same year, SDC "established a new hardware department" based on their anticipation of a "need for strong hardware capability". (Id.)

In 1979, SDC stated that it had "embarked on a program for the design, manufacture, and marketing of commercial hardware products." According to SDC, "[p]roduct development is a natural evolution of SDC's historic role. Over the last decade, we have integrated hardware and software into efficient information systems for many customers." (DX 12390, p. 7.)

In its most recent annual report, SDC summarized the progress it had made in the 1970s and set forth its "outlook" for the future:

> "The 1970's were a period of transition for SDC. We augmented our software systems skills with hardware and communications capabilities to meet government and industry needs for total turnkey systems. The resulting growth in our traditional markets, coupled with successful thrusts into energy, health care, and commercial trans-

action services, brought a near fourfold gain in sales volume, from $45 million in 1971 to $166 million in 1979.

"The next decade promises to be equally challenging and rewarding for SDC, its employees and stockholders. As we begin the careful process of developing unique components for our systems that will allow us to offer superior systems to our traditional customers, we are also creating components which we believe will make attractive commercial products." (DX 12390, p. 7.)

(iii) Computer Sciences Corporation. Computer Sciences Corporation (CSC), whose formation and first decade of development we outlined in the 1960s portion of this testimony, continued its growth through the 1970s. CSC's revenues climbed from $177 million in 1975 to $452 million in 1980. (DX 12296, p. 2; DX 13947.)

CSC offers "contract services" and "data services". The company describes contract services as "services performed to a client's contractual specifications." Those services range from the development of custom-designed systems, to the "management of a client's complete computer requirement." CSC describes its data services as consisting of "proprietary services such as INFONET* that are marketed to numerous clients, transaction services for a specific industry or market, and other data base-oriented or applications-oriented computer services." (DX 12298, p. 4.)

(a) Contract Services. CSC provides contract services to both government and commercial end-users. For federal, state and

* As described earlier (see p. 863 above), INFONET is CSC's communications network that links users to CSC's computer service bureau.

local governments, CSC has assisted in developing a variety of systems. For example, it is developing a Medicaid management information system for the State of California and is providing a turnkey message switching system to Orange County, California to improve "public safety services".* It also provides computer systems engineering and data processing services to Johnson Space Center, and has developed systems to support the data processing needs of 200 Veterans Administration hospitals. (DX 12298, p. 7; DX 14213, pp. 3, 10.)

For commercial users CSC has developed on-line order-entry and inventory control systems, monitoring and control systems for production applications and systems for medical applications. (DX 12775, pp. 7-8.)

One of CSC's major areas of contract services work has been in the development of intercomputer networks for the Worldwide Military Command and Control System and the Autodin II program, "the Defense Communications Agency's advanced automatic digital information network". (DX 14213, p. 12; DX 12298, p. 6.) CSC provides systems engineering support for the Autodin II network. (DX 12298, p. 6.) In 1979, CSC noted that the technology it was developing for the Worldwide Military Command and Control System and Autodin II "is directly applicable to the growing commercial market for data and

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* CSC noted that the "increasing use of computers as communications switches opens promising new markets for CSC's diverse capabilities." (DX 12297, p. 7.)

computer networks requiring fast, reliable communications between a variety of host computers and remote terminals." (DX 14213 , p. 12.)

(b) Data Services. The agencies of the Federal Government have been major users of INFONET Services. In 1976, CSC reported that the General Services Administration had extended its INFONET Services contract and that GSA had inaugurated "a new Teleprocessing Services Program aimed at greater use of remote services companies in meeting Federal Government requirements for computing capabilities." (DX 12296, p. 6.)

Private corporations also use CSC's INFONET system. In 1978, Computer Sciences reported that "[m]ore than a quarter of the Fortune 500 companies and hundreds of smaller organizations use INFONET in such aspects of their operations as manufacturing, marketing, finance, distribution, administration and corporate planning." (DX 12298, p. 9.) CSC has acknowledged that in building its INFONET Services they have applied the "technical and management strengths established" in their contract services business. This has resulted in "a structure of computer centers, network communications and software . . . which provides a highly reliable and cost-effective means of meeting the broadest of client requirements." (DX 12298, p. 9.)

As this statement indicates, the software they have developed for their network is fundamental to CSC's service offerings. CSC developed a proprietary software system called Computer Sciences Teleprocessing System which has, according to CSC, "resulted in a significant improvement in services to clients." (DX 12297, p. 11. CSC has also developed a library of application programs to assist its clients:

> "Emphasis has been placed on systems for financial analysis, reporting, planning, budgeting and forecasting; manufacturing applications; banking applications; scientific-engineering applications, and general accounting applications. Increased investment in products will be made in the coming years as standard product concepts become more widely accepted by the user community." (DX 12297, p. 11.)

In 1979, CSC summarized the development and uses of its INFONET offerings:

> "[T]he Company has invested its technology and resources in the creation of a worldwide computer-communications network service called INFONET, that our clients use on a shared basis as an alternative to the use of their own computer-communications facility. INFONET fulfills clients' needs for time-critical decision information, specialized analyses, and the rapid consolidation of data from widely dispersed locations. In addition to offering exceptionally high system reliability and availability, INFONET provides advanced data management systems, and a large number of specific applications programs for clients' use in developing highly sophisticated information systems. An extensive field services organization provides ready support to clients in their use of the service." (DX 14213, p. 8.)

In 1978 and 1979, CSC enhanced its data services offerings in several ways. In 1978 they announced a "data base product", called "MANAGE" as well as new "applications products". (DX 12298, p. 9.) CSC reportedly also offers, through INFONET, data base management capabilities utilizing MRI's System 2000 and TRW's Generalized Information Management System. (DX 13160.) In 1979, CSC introduced "a comprehensive financial system known as FLARES II, which has been integrated with the highly successful data management system called MANAGE to provide a potent means of consolidating, analyzing and reporting financial information." (DX 14213, p. 16.)

In 1977, CSC explained that "the integration of mini-computers into the [INFONET] network to handle distributed computing applications" offered CSC "new opportunities . . . by providing cost-effective solutions to many applications with large data requirements." (DX 12297, p. 11.)

In 1980, it was reported that CSC had introduced Distributed Network Services, which combines CSC-provided DEC PDP 11/23 and PDP 11/44 processors, configured to CSC specifications, and CSC software with INFONET's communications and computer facilities. It was also reported that a subset of CSC's MANAGE data base management system had been implemented to operate on these DEC computers. A user can, with this offering, distribute functions and data bases throughout his organization and integrate them into a total system. (DX 14238.)

b. <u>Service Bureau/Time-sharing Companies.</u> As discussed earlier, in the 1970s a number of computer equipment manufacturers, including CDC and Xerox, offered a variety of sophisticated data processing services. There were, in addition, many service bureau and time-sharing companies that were offering computing services to users as alternatives to the installation of in-house computer equipment--either entire systems or equipment additions to already installed systems.

(i) <u>Automatic Data Processing, Inc. (ADP).</u> ADP was already twenty-one years old in 1970 and had "created a broad librar of computer programs" available to users. (DX 10321, pp. 5, 14.)

In the 1970s, ADP continued to broaden its offerings. For example, in 1972, ADP began to offer "[f]or the first time . . . order-entry, billing and inventory services via terminals in the clients' offices" which were to be connected to ADP's computer complex through a nationwide network of dedicated telephone lines. ADP stated:

> "Entering the on-line services field gives ADP access to a large new market of companies, including many with in-house equipment, and national organizations with multi-state operations. Additionally, the company can now offer these important new services to existing clients as well." (DX 10321, p. 6.)

Other services available were accounts receivable, sales analysis, profit analysis, payroll, accounts payable, general ledger, financial statement preparation and a host of analytical management reports. This development meant that it was "no longer necessary for ADP's [office] to be within a relatively short distance of the company's computer center: potential customers can be reached almost anywhere in the country". (Id., p. 12.)

ADP began to expand overseas as well. In 1976, it acquired a London-based data services company, with offices throughout the United Kingdom, and began offering data services in South America. It served these clients through "an international data communications network" with "sophisticated problem-solving and data base management programs". (DX 12277, pp. 5, 15.)

Also in 1976, ADP introduced its AUTOPAY III, an "on-line payroll system designed to meet the needs of medium and large, multi-location companies". A client is able to have its payroll processed by entering the data through its own on-premises terminal. (DX 12277, p. 10.)

By 1977 ADP, which in 1967 had called itself primarily a payroll company, offered more than 20 major products (DX 12278, p. 4) and styled itself a "leader" in the development of proprietary application packages for its time-sharing network. In addition, it offered an extensive line of data base applications in finance, securities analysis, economics, foreign exchange rates, demographics and chemistry. (Id., pp. 21-22; see also DX 11205.)

In the 1970s, ADP also began to market hardware products. For example, in 1975, ADP first reported that it had developed a "mini" computer system, which it programmed to deliver service similar to that provided by ADP's central installation, for on-line clients with large processing volumes at their locations. The first applications for the mini-computer service were inventory control and accounting. (DX 12276, pp. 8, 10.)

In 1978, the company introduced "ADP/Onsite", a service that places an "extremely powerful" computer on the user's premises that is compatible with ADP's time-sharing services and is connected to and operates as part of the ADP international teleprocessing network.* ADP said that the service "combines the advantages of remote computing services and in-house systems" (DX 12279, p. 3), that the on-site computer can perform local processing and can access the ADP computer network which is said to provide a "wide variety of data bases, four standard languages, customer programming assistance and the kind of day-to-day support that only service companies provide". (DX 11145; see also DX 12279, p. 3.)

By 1979, ADP served more than 75,000 users and provided computing services to "virtually every area of industry, finance and government". Its revenues in that year were $371 million. (DX 14328, pp. 2-3.)

(ii) <u>General Electric.</u> General Electric entered the 1970s with a highly successful time-sharing/service bureau business. At the time GE merged its computer business into Honeywell, GE's Ventures Task Force recommended that the company retain its services

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* ADP also has under development a "new generation" computer system for stand-alone applications. It now claims that "all elements of the service including equipment, software and client support are available from a single source". (DX 12279, p. 10.)

business, which it did. (See above, pp. 541-42.) That business was quite successful during the 1970s:

(a) In 1973, GE stated that "[i]n serving a broad spectrum of customers in business, industry and government, GE's information services operations moved to new highs in sales and earnings". (DX 14216, p. 17.)

(b) By 1977, GE reported that its information services business "continued to grow sales and earnings as over 5,000 customers around the world make use of its extensive line of computing services. . . . A new layer of growth has been added by the marketing of complete business system services, such as financial consolidation, cash management and order service". (DX 13981, p. 16.)

(c) By 1979, GE reported that its computer service network reached over 600 cities in 24 countries. (DX 11536.) According to GE, its network was comprised of over $100 million in equipment and was the "world's largest commercially available teleprocessing network". (DX 11534.)

(d) For 1979, Datamation estimated GE's data processing revenues at $350 million, and ranked it 17 in the "Top 100" companies. (DX 13945, p. 7.)*

The varied uses of GE's computer services by ten of its

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* In 1969, the last full year before the GE/Honeywell merger, GE's U.S. EDP revenues were $219 million. (See DX 8224, p. 6, DX 8631, pp. 31, 33; DX 14484.)

customers are described in Defendant's Exhibit 14333, a GE publication. A selection from several of those descriptions illustrates the use of GE's time-sharing services:

(a) Hospital Corporation of America (HCA). HCA owns and/or manages nearly 100 hospitals in 24 states and 2 foreign countries. It uses GE's computer services to perform a variet of applications, including: patient census information, billing, accounts receivable, general ledger and credit collection According to an HCA Vice President and Controller, HCA was able, through use of GE's services to return "'seven computer systems, eliminated six outside data processing services, and remov[e] a great deal of manual posting equipment. . . ." (Id., p. 8.)

(b) The Wurlitzer Company. The Wurlitzer Company manufactures musical instruments. It uses GE's computer services combined with software developed by an accounting firm to perform financial control, budgeting and monthly consolidation accounting. According to Wurlitzer's Controller, the company chose not to implement the applications on its in-house System/360 Model 40 for four reasons:

(1) the in-house system "'was already loaded to capacity with operational programs, marketing analyses, payroll, and the like'";

(2) "'the programming staff didn't have time to create the software we needed'";

(3) "'it wasn't cost-effective anyway if you consider the value of our programmers' time against the cost of an already-developed, tested and proven system'"; and

(4) "'we got special features via GE's computing service that simply weren't available internally'". (Id., pp. 14-15.)

In addition to its data processing services, GE also was marketing computer hardware as well as maintenance services in the 1970s. For example:

(a) GE markets a line of computer printers and communications controllers, the "TermiNet" family, which, according to GE, are capable of emulating Univac and IBM remote print stations. (DX 2770A; DX 11526; DX 11527; DX 11528.)

(b) In the late 1970s, GE began offering the Marklink III computer system, as a "new approach for distributed data processing". According to GE, the Marklink III "minicomputer" is manufactured by Texas Instruments and may operate at a customers' location as part of GE's computer network. (DX 13234.) The Marklink III is advertised as being capable of performing local processing or of functioning with GE's computer network in distributed processing and time-sharing configurations. (DX 11537.)

(c) A GE subsidiary, General Electric Credit Corporation, is engaged in leasing computer equipment and, by 1978, had over $600 million of such equipment on lease. (DX 11538; see also

p. 1040 above.)

(d) Also, GE advertises that the company offers computer maintenance for "computers of other makes" and offers its maintenance services on a worldwide basis "to OEM's and computer manufacturers who need a ready-made service organization". (DX 11529.)

(iii) McDonnell Douglas Automation Company (McAuto). McDonnell Douglas Automation Company was formed in 1970 from the consolidation of in-house computer service organizations throughout the McDonnell Douglas Corporation and the former McDonnell Automation Company, which had been operating as a service bureau since 1960. (DX 11075, p. 12; see p. 846 above.) In 1970, McAuto's revenues were about $47 million. (DX 11075, p. 12.) For 1979, the company was ranked 25th in data processing revenues in Datamation's "Top 100" company list, and its revenues from data services were $150 million.* (DX 13945, p.7.)

During the 1970s, McAuto expanded the scope of its announced offerings to include:

(a) A service called CO-OP--Customer On-Line Order Processing System. According to McAuto, by renting this CO-OP "system" and acquiring only terminal equipment, which would be

* McAuto's total data processing revenues for 1979, including those from Microdata, a computer manufacturer acquired in 1979, were estimated to be $253 million. (DX 13945, p. 7.)

located in the customer's premises, a customer could process orders, handle inquiries, print acknowledgments and screen parts sent out against its inventory. (DX 11765.)

(b) The LAND package, which performs subdivision platting for condominium and shopping projects. (DX 10324, p. 40.)

(c) The Automated Shareholder Records System (ASRS). McAuto reported that this software program is used by corporations, such as Continental Oil, Pet, Inc. and Boise Cascade to keep track of shareholder data. (DX 11763.)

(d) An inventory control system. According to McAuto, an example of its inventory control system is American Honda Motor Co., Inc., which uses the system to manage a 50,000 item parts inventory; remote terminals in Honda's parts centers are linked to McAuto's computer center where inventory records are stored. (DX 11764.)

(e) A facility planning service and an educational management service. (DX 10324, pp. 16, 42.)*

By 1979, McDonnell Douglas, McAuto's parent, announced that it had formed a subsidiary, the McDonnell Douglas Finance Corporation, to engage in the leasing of "major equipment", including computer systems. (DX 11766; see also DX 11767.)

Also in 1979 McDonnell Douglas acquired Microdata

* McAuto has also continued to offer systems design and consulting services (see p. 847 above) and to advertise its expertise in data base management systems. (DX 11762.)

Corporation, which had about $94 million in revenues in 1979. (DX 12355, p. 10.) Microdata manufactures several lines of computer systems including the "Reality" family. In 1979, Microdata expanded the Reality line: three models were said to compare in performance with the IBM System/34 and System/38, Univac BC/7 and NCR's 8200 series (DX 13739, p. 2); the fourth and largest model reportedly supports up to 512 thousand bytes of main memory, 514 million bytes of on-line disk storage and the Reality data base management system. (DX 13741.)

For the 1980s McAuto has predicted that its move towards providing computer power at the customer's site, to do both local processing and distributed processing in conjunction with the McAuto central network, will accelerate. According to McAuto's Marketing Vice President:

> "'Making distributed processing viable and real provides a major area of expansion for McAuto in the '80s.'" (DX 14261 .)

c. Exxon Corporation. During the 1970s Exxon--the nation's largest industrial firm with 1979 revenues of $84 billion--entered the computer industry. (DX 14330, pp. 24, 27; DX 13946, p. 3.) Its entry was accomplished through the acquisition of several companies over the past eight years. Three of these companies operate as divisions of Exxon Enterprises and five, in which Exxon holds in excess of a 50 percent interest, are run as affiliates. (DX 14330, p. 24.) For 1979 Exxon reported that the combined revenues of these companies had reached $194 million, which represented a more than 100 percent increase over the previous year. (Id.) A brief survey of the offerings of some of Exxon's information systems companies exemplifies the data processing capabilities that Exxon is assembling.

(i) Zilog, Inc. Zilog started business on May 15, 1975, and soon thereafter received financing from Exxon. According to Dr. H. Dean Brown, who joined Zilog on its first day of business, Exxon's interest in Zilog is "substantially" in excess of 50 percent. (Tr. 82979.)

Zilog's product line ranges from chips to microcomputer systems. (Brown, Tr. 82979-80.) In a 1975 paper on microprocessors, Brown stated: "'[A]s the application of micros expands and as LSI technology continues to advance, all desirable megacomputer* features will be incorporated into micros'". (Tr. 83422,

* Brown described "megacomputers" as "very large. . . . general purpose electronic digital computers". (Tr. 82959.)

83430.) In 1978, Dr. Brown testified that that development had in fact "happened faster" than he had thought it would. (Id.)

Brown described Zilog's microcomputer systems as of the time of his testimony in 1978 as "a complete line of general purpose[*] electronic digital computer systems . . . ranging in price from $6,000 to $18,000." (Tr. 82980; DX 13048, p. 2.) Among these systems is the MCZ 1/90, which consists of "three boxes--one housing a Z80 CPU chip and 64K of memory; one housing a Z80 CPU chip, CRT display and 16K of memory; and one housing a Z80 CPU chip, a 10 megabyte hard disk and 16K of memory." (Tr. 82981; see DX 13063, p. 13; DX 13812, pp. 1-2; see also DX 13062.) The software that Zilog makes available for the MCZ Series includes an operating system and programming languages such as BASIC, FORTRAN IV, 1974 ANSI standard COBOL, Level 1, and a variety of utility packages. (Brown, Tr. 82982; DX 13048, pp. 6-7; DX 13054, p. 1.) Zilog advertises that the disk capacity of the MCZ 1/90 can be expanded to 40 million bytes. (DX 13063, p. 2.)

The capabilities of Zilog's microprocessors are quite remarkable. For example, one Zilog advertisement offered this description of microcomputer capability:

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* Brown defined "[g]eneral purpose" to mean:

> "that a configuration of hardware and software can be used for a wide variety of applications, including for example, administrative, manufacturing, commercial, scientific, communications, word processing or process control applications, under the control of a stored program." (Tr. 82958.)

"To give you some idea of just how powerful a microcomputer is, consider this. In 1947, the first electronic digital computer, ENIAC, was a fickle 30-ton monster consisting of 18,000 vacuum tubes and a spaghetti-festival of electronic wiring. Cost: $500,000.

"A Zilog microcomputer, on the other hand, packs over twenty times ENIAC's computational power onto a less than quarter-inch-square silicon circuit wafer. Cost: under $10.00 in quantities." (DX 3829, p. 5.)

The instruction sets for the Z80 CPU and the IBM System 360 Model 50 "are equivalent in terms of the functions that they perform." (Brown, Tr. 82984.) Yet the Zilog MCZ computer systems have a purchase price ranging from $6,000 to $18,000 while in the middle sixties the purchase price from IBM for an IBM System/360 Model 50 central processing unit and memory alone--without any other peripheral equipment--ranged from approximately $400,000 to $1 million. (Brown, Tr. 82991-92.) And a Zilog microprocessor could perform the calculations analyzing the Ivy shot, the first thermonuclear explosion (Brown, Tr. 82961), in one week compared to the five months it took the ENIAC, SEAC, UNIVAC and MANIAC systems to perform that work. (Brown, Tr. 82984.)

By 1978, Zilog had announced the Z8000 chip which has a 16-bit word length, is faster than the Z80 "by a factor of five to ten and is a significant advance over the Z80 in terms of its ability to support parallel processing, networking and file maintenance." (Brown, Tr. 82984-85; see DX 14291.) As is the case with the Z80, the Z8000 has an operating system and supports various languages such as BASIC, COBOL and FORTRAN. (DX 13073,

p. 3.) Zilog claims that the Z8000 is "faster than the [DEC] PDP 11/45 and only slightly slower than the PDP 11/70." (Id., p. 4.)

Zilog microcomputers are used for "[a]pplications for businesses", "[e]ngineering and scientific applications", "intelligent terminals" and "part of other computer systems as a front-end processor". (Brown, Tr. 82985-86.) Zilog components (boards and chips) are also "used in a wide variety of peripheral products. (Brown, Tr. 82987.)

At the time of his testimony in 1978, Brown was in the process of forming a new company called Picodyne to "sell complete computer systems to end users for a wide variety of applications, including accounting, communications and process control." (Tr. 82987-88.) Picodyne's "strategy" is to market Zilog computer systems and application software developed jointly by Picodyne and users. (Tr. 82988.) Brown testified that, "[i]n deciding to form Picodyne, I had to take into consideration the competition that Picodyne would face from a variety of companies, including IBM". (Tr. 82990; see also Tr. 83141-55.) According to Brown, that "[c]ompetition does not let us sleep"-- "us" meaning "Picodyne, Zilog and the computer companies I have worked with and that I have observed." (Tr. 83814.) Brown stated:

> "When I say we can't sleep, it doesn't mean that we are worried; it means that we are busy, and we are working late at night and on weekends, and we get up very early in the morning and run fast and run hard." (Tr. 83892-93.)

That competition includes IBM because:

"First, IBM manufactures machines like the 8100 and the 5110 which are directly in our product area, and they also manufacture hardware that supports time sharing services, both commercial and in-house, and as IBM technology gets better, it means that price/performance, cost of good performance, gets lower from these alternative sources, and eats into our [Zilog's and Picodyne's] potential profit margin." (Tr. 83893.)

It is that "vigorous competition between vendors to serve the users", together with "breakthroughs in research [and] imaginative applications" which was the basis of Brown's opinion that the "rate of technological development in the computer industry has been astounding." (Tr. 82991.)

At Zilog there is a "working premise" "built into our growth plan--that we will have such financing as is necessary to become a successful computer company in the long term" and an assumption that "financing from Exxon will be there on any reasonable scale." (Brown, Tr. 83170.) Brown testified that "[i]n addition, it is our feeling in the industry--I want to clarify 'our', meaning my peers that I work with, both in Zilog and in other companies--that ready capital exists for all these companies in our area provided the management demonstrates its ability to make good use of it." (Tr. 83170.)*

(ii) Periphonics Corp. Periphonics, which is a wholly-

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* By "our area" Brown meant "the manufacture and sales and services of computers that perform business, scientific, administrative, engineering and process control operation." (Tr. 83177.)

owned affiliate of Exxon, offers a variety of communications and terminal products. (DX 14270.) Periphonics markets the T-COMM Communications System that includes a "programmable telecommunications processor . . . designed to support a wide variety of terminal devices", including those offered by IBM, Burroughs and NCR. Periphonics advertises that T-COMM can effect the communication between terminals and an IBM processor without the use of IBM telecommunications access methods, network control programming or the "one megabyte of memory" or "extra CPU cycles" needed to support that software. (DX 11880.) In addition, Periphonics markets add-on memory for DEC PDP-11 computers, which can extend the main memory of a PDP-11 to 2 million bytes. (DX 14271.)

(iii) Ramtek Corp. Ramtek Corp., in which Exxon owns a minority interest, manufactures graphics and other intelligent terminals. (DX 13000; DX 13003; DX 14250.) The Ramtek 9000 series terminals, for example, are programmable, microprocessor-controlled, graphics terminals with a main memory expandable to 16 thousand bytes. (DX 13000, DX 13003, p. 2.) Ramtek also offers stand-alone graphics terminals which include a Zilog Z80 microprocessor that functions as a terminal controller. (DX 14276; DX 14275A.) Ramtek also offers the 8000 series of programmable intelligent terminals, which includes models that emulate certain Univac Uniscope terminals. (DX 14274.)

(iv) Vydec, Inc. Vydec, a division of Exxon Enterprises ("the new business development arm of Exxon"), manufactures and markets word processing systems. (DX 3829, pp. 2, 6.) In 1979, it was reported that Vydec had announced new word processing systems built around Zilog Z80 microprocessors. The largest system includes six Z80s and supports up to 64 thousand bytes of main memory. Vydec reportedly stated that a 128 thousand byte memory expansion will be announced in the future. In addition the system offers two Shugart mini-diskette drives, printers and a communications processor that permits Vydec word processors to communicate with similarly equipped Vydec and other processing equipment as well as Telex and TWX networks. Finally, Vydec reportedly stated that its new word processors will, in the future, be equipped with the ability to emulate IBM 2780 and 3780 terminals. (DX 14285 .)

In 1980 Vydec announced its 1800 word processor which is said to offer, among other things, a Records Processing Package allowing users to maintain a data base of records, and a Math Package that handles certain calculations. (DX 14284 .)

In July 1980 Vydec announced a shared resource office system. This system is said to consist of a microprocessor-based system controller or CPU, various Vydec work stations and Exxon's QYX intelligent typewriter.* The controller is also said to be

* QYX, a division of Exxon Enterprises, manufactures "The Intelligent Typewriter". (DX 3829, pp. 3, 6.) QYX typewriters can be equipped with memory and diskette storage and can communicate with other QYX machines, Vydec word processors and with computers. (Id.)

attachable to other word or data processing systems. The controller can support up to 75 million characters of disk storage and can address up to 1 million bytes of directly addressable memory. (DX 14249.)

(v) Others. Exxon has interests in several other companies of interest in this area.

(a) Exxon owns Qwip, which manufactures facsimile transmission equipment. Exxon advertises that Qwip is placing more facsimile machines than any other company. (DX 3829, p. 4.)

(b) Optical Information Systems, Inc. is 100 percent owned by Exxon and manufactures semiconductor laser products for computers. (DX 14250.)

(c) Dialog Systems, Inc. is an affiliate of Exxon Enterprises. Dialog reportedly manufactures speech recognition equipment for voice input and voice response for computer data entry, information retrieval and telephone network applications. According to Dialog, their products permit "users to transmit data directly to and retrieve data directly from a computer by speaking over any telephone." (DX 12821.)

74. Foreign Competitors. American computer manufacturers generally plan, develop, manufacture and market their computer product lines "on a worldwide basis".*

Akers, IBM Vice President and Group Executive for the Data Processing Marketing Group, explained that the competition which IBM faced from foreign competitors, specifically Japanese and European competitors, affected the development of IBM's product line in the United States:

> "The product line is a world wide product line. Many of our customers are world wide customers. Businesses in the world industry are located all over the world. Customers wish to have products that they can utilize in Brazil and Japan, the United States, in England and they want to be able to operate their business in similar fashions if they so desire.
>
> "The world-wide requirements for the product line developed by the Data Processing Product Group are a fundamental part of my responsibility in the requirements area, as I have indicated, and absolutely affect the plans for the product line that is marketed in the United States, in Japan, in other countries around the world.
>
> "Q. Can you explain how the product line is affected?
>
> "A. The product line is affected in its plans to meet the needs of customers around the world. The needs of our customers in Japan are very often similar to the needs of our customers in the United Kingdom, in Canada and the United States, and very often those needs are more effectively communicated, are very often earlier understood by the

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* Hindle, Tr. 7386-88 (DEC); see, e.g., Akers, Tr. 97009-010, 97012-13, DX 1404A, pp. 56, 98, (App. A to JX 38), DX 3359, pp. 6-7, 9-10 (IBM); DX 426, p. 19, and DX 484, p. 5 (Burroughs); G. Brown, Tr. 51550 (CDC); DX 12310, pp. 3, 20-21 (Data General); DX 12335, p. 5 (Hewlett-Packard); Spangle, Tr. 5202-04, 5213, Binger, Tr. 4567-68 and DX 151, pp. 201565 (Honeywell); DX 12348, pp. 16-17 (MAI/Basic Four); DX 340-A, p. 20, DX 364, DX 366, p. 11, DX 809 (NCR); DX 12607, p. 24 (STC); McDonald, Tr. 3839 (Univac); Withington, Tr. 57618.)

marketing units in another part of the world than the U.S., and that's a way in which that effect takes place." (Tr. 97012-13; see Tr. 97035-36.)

In this worldwide business, IBM and other American companies have faced increasingly aggressive competition from their foreign rivals, both inside and outside the United States. The parties have agreed that as of 1975 IBM competed abroad with "many European and Japanese companies" "in the marketing of EDP products and services" and listed 208 foreign competitors of IBM. (DX 4904, ¶¶ 1.0-1.208, 2.14.6, 2.14.13, 2.14.19, 2.17.5, 2.26, 2.26.2, 2.33.2, 3.3.0, 3.5.1-.2, 3.8.8, 3.8.15, 3.9.0, 4.19.12.)

Moreover, IBM's foreign competitors are getting stronger, expanding their operations around the world (id., ¶¶ 2.0, 2.5.1, 2.14.0, 2.14.23, 2.17.0-.1, 2.30.6, 2.32.3-.4, 2.34.0, 2.35.0, 2.37.0, 2.37.4-.5, 2.38.6, 3.6.0, 4.9.0-.1, 4.20.0-.1, 4.21.0, 4.22.1, 5.0, 5.1.0, 5.1.1, 5.5.0, 5.6.0-.1) and especially in the United States. (See below, pp. 1259-73.) As a result, a "number of the technological and marketing advantages once enjoyed by IBM and other U.S. EDP suppliers have been decreased". (DX 4904, ¶ 3.0.)

The growing size, technical capability and government support of foreign computer manufacturers is a matter of some significance to an understanding of the computer industry in the Seventies.

a. Japanese Manufacturers. Henry Rosovsky, Dean of the Faculty of Arts and Sciences at Harvard, testified that the Japanese have made "the EDP industry . . . a national priority industry of the highest order." (Tr. 100853; see also 100742, 100839-41.)

Dean Rosovsky also noted that the computer industry is "peculiarly suited" to the Japanese because of the "technologically sophisticated" nature of the industry. (Tr. 100839-41.)* His view is, of course, supported not only by the Japanese successes around the world in other electronic industries--radios, TV, home videotape recorders (DX 14292)--but also by the expressed policy of the Japanese government: "The official policy of the Japanese Government has been to strengthen the Japanese computer industry." (DX 4904, ¶ 13.1.0.)

Under government guidance, the major Japanese companies have already been paired into three groups of two companies each: Fujitsu/Hitachi, Nippon Electric/Toshiba and Mitsubishi/Oki. "They are paired together for purposes of research and development activities and certain other activities. It is conceivable that [there will be further consolidation] into other groups . . . ." (Rosovsky,

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* This conclusion, and others reached by Dean Rosovsky which are discussed in the following pages, are confirmed by the content of several documents reviewed by the witness and relied upon by him during his testimony: DX 8051, "Computer White Paper 1976 Edition", by Japan Information Processing Development Center; DX 8049, "The Computer Industry in Japan and Its Meaning for the United States", by the Computer Technology/Resources Panel of the Computer Science and Engineering Board of the National Research Council (distributed by the U. S. Department of Commerce); PX 6612 (DX 14513), "Computer White Paper 1977 Edition", by Japan Information Processing Development Center; PX 6610 (DX 14512), "United States Japan Trade: Issues and Problems", by the Comptroller General of the United States. None of these documents was offered in evidence.

Tr. 100837-38.)

These companies, however, are quite large in their own right. As listed in Fortune's 1978 Directory of the 500 Largest Corporations Outside the U.S. (DX 8053)--Hitachi ranked 23rd, with over $9 billion in sales, Toshiba ranked 40th with over $5.7 billion in sales, Mitsubishi ranked 84th with over $3.2 billion in sales, Nippon Electric ranked 106th with over $2.7 billion in sales, and Fujitsu ranked 205th with over $1.5 billion in sales. And Fujitsu, Hitachi, Mitsubishi, Nippon Electric each "has a growing EDP business". (DX 4904, ¶¶ 2.34.0, 2.35.0, 2.36.0, 2.37.0.) These figures also do not take into account the web of "family" relationships among Japan's industrial and financial institutions. Fujitsu, for example,

> "is a member of the Furukawa Group consisting of Daiichi Kangyo Bank, Asahi Mutual Life Insurance Co., Nippon Light Metal Co., Furukawa Mining Co., Fuji Electric Co., Furukawa Electric Co., Asahi Denka Kogyo, the Yokohama Rubber Co., and the Nippon Zeon Co." (DX 4904, ¶ 2.34.1.)

In 1972, this "Group" had "manufacturing sales" of over $3.8 billion (Id., ¶ 2.34.2.)

Nevertheless, the Japanese Government "subsidizes Japanese computer manufacturers" (DX 4904, ¶ 13.4.1) and gives assistance through "special depreciation allowances for the industry, the sharing of developmental costs, special tax concessions, export subsidies in some cases, and other measures of a similar kind". (Rosovsky, Tr. 100848-49, see also Tr. 100852-53.)

Dean Rosovsky testified further that the EDP industry "has considerable export potential for Japan not only in the United States but in other parts of the world as well". (Tr. 100853-54.) "[T]hese Japanese companies intend to sell their electronic data processing equipment--well, indeed, they are already doing so--throughout the world, including American markets." (Tr. 100837.)

Dean Rosovsky predicted that by 1990 the Japanese would "have a significant share in American markets. . . . I would not be surprised if their share was similar to that that now pertains in the automobile industry. . . . [w]hich I believe is roughly 18 percent. . . ." (Tr. 101001-02.) Dean Rosovsky concluded by stating that his testimony "is designed really to suggest we should take Japanese intentions [seriously]. We have often not taken them seriously, much to our dismay later." (Tr. 101002-03.)

The basis for his opinion that "these companies will expand their activities in American markets . . . . [i]s the way in which Japanese industries have traditionally developed, the importance of the electronic data processing industry in Japan, [and] the way it has been targeted." (Rosovsky, Tr. 100838-39.)

The Japanese certainly have the technical capability and products to meet their goals. Japanese computer companies manufacture and market a full menu of computer products, from the LSI semiconductor components to peripheral equipment of all kinds, to some of the largest computers in the world. (DX 12676, pp. 14, 15, 17, 19; DX 9415.) Akers testified that Japanese computer companies "have provided computer products that were superior to any other that were available anywhere in the world". (Tr. 97011.) One area he singled out where the Japanese exhibited "leadership" was large processors. (Tr. 97011.) "They have been successful in developing and announcing for marketing not only in Japan but here in the United States processors with more power than the IBM company. That is an example of leadership." (Id.)

The sophistication of the Japanese industry is especially evident in its response to IBM's Model 4300. Within six months of that announcement, NEC, Mitsubishi, Fujitsu and Hitachi had all announced competing products. (See below, pp. 1329-30, 1333-34.)

In addition, the Japanese are already exporting significant amounts of computer and computer-related products to the United States.

First, Japanese semiconductor components. The U.S. Semiconductor Industry Association has estimated, according to reports, "that the Japanese had captured 42% of the American memory market". (DX 12676, p. 4.) According to Withington, they have "a major participation in semiconductor electronics sold to the computer manufacturers here". (Tr. 112918-19.)

Japanese technological progress often equals or surpasses that of IBM. The Japanese manufacturers are the only ones, besides IBM, for example, to have developed the "flip chip" technology, a production process which produces logic circuits with higher yields, reliability and density than other manufacturing processes. (See E. Bloch, Tr. 91703-11.) The Japanese manufacturers have also developed the use of E-beam technology to produce memory and logic circuits--a process which increases yields, reliability and density. (See E. Bloch, Tr. 92516-92521.)

The Japanese semioonductor effort appears to be increasing: In the United States, it was reported in October 1979 that Fujitsu had committed $10 million for the construction of a memory and logic assembly facility in California, and Hitachi is completing an assembly plant for semiconductor memories in Texas. (DX 14413.) In Japan, the government has helped Japanese companies fund research and development efforts. The Japanese companies have organized laboratories under government supervision which combine engineers and scientists from various companies and develop semiconductor technology in a particular area. (E. Bloch, Tr. 93437-38.) For example, the Japanese government is "funding a sizable effort"; Bloch testified: "I think I saw the number 30 or 40 million dollars . . . for a research program in Josephson [technology], and that work is being done by Fujitsu in behalf of the Japanese government." (Tr. 93434.)

The Japanese competitors are part of a program "sponsored by the Japanese Government called the VLSI effort or very large scale integration effort, that is developing products, circuits, tools for the manufacture of these components and that is also developing computer products and doing research in computer products." (Bloch, Tr. 91963.)

In October 1977, Bloch gave a presentation to IBM's

Corporate Management Committee (CMC) concerning IBM's future semiconductor developments and Japanese VLSI developments. The presentation is DX 9165, which has been sealed by the Court. Bloch termed the Japanese project "aggressive" and compared the expenditures of IBM in its Stanford Program, an effort to develop very large scale integrated circuitry, to the expenditures made by the Japanese in the VLSI project. Both efforts involved approximately $500 million. (E. Bloch, Tr. 93490-91.) Bloch testified that development of VLSI circuitry requires extensive investment for IBM and its competitors and that the Japanese undertaking "is the single-most comparable effort since the Stanford Program". (Tr. 93497.)

The significance of the Japanese capability in advanced semiconductor operations cannot be underestimated--particularly in light of the track record of this country's own semiconductor manufacturers who have entered the computer business in the last decade or so: Texas Instruments, National Semiconductor and Intel to name a few. (See above, pp. 1199-1207.)

Bloch testified that in IBM's research and development work, IBM had to take "into account the work that Hitachi and Fujitsu are doing in the development and manufacturing of components." (Tr. 91962-63.) He testified that it was necessary to follow the technological developments of Japanese companies, as well as the developments of other competitors, because

"I have to understand it in order to judge the work that we are doing ourselves, that we in East Fishkill are doing ourselves to see the state of the art, to see how competitive it is and to understand what the competitive pressure is that we are encountering today or will encounter." (Id.)

Second, Japanese computer products are already being marketed in the United States. For example:

(i) National Advanced Systems is marketing Hitachi computer systems in the United States. (See above, p. 1207.) In addition, Hitachi markets bubble memory to CDC and printers to Centronics. (DX 9415.)

(ii) Fujitsu owns about 41% of Amdahl and provides Amdahl with CPU subassemblies. Moreover, Fujitsu has just entered into a joint venture with TRW through which TRW will market Fujitsu computers in the United States. (Withington, Tr. 112916; DX 14121; DX 4354, p. 2.) In addition, Fujitsu markets high-speed tape drives to Memorex (DX 9415; DX 14262) and Winchester-type disk drives to OEMs. (DX 14355; DX 14356.) It also supplies 64K memory chips to NCR, and logic to CDC for the STAR computer. (DX 9415.)

(iii) Nippon Peripherals Ltd., a joint venture of Fujitsu and Hitachi, markets its advanced tape and disk subsystems through Memorex in the U.S. (DX 12830; Navas, Tr. 39713-14.)

(iv) Nippon Electric Company markets small computers in the United States through a U.S. subsidiary, NEC Information Systems. (DX 9415; see Withington, Tr. 112917-18.) In addition, Honeywell uses systems control programming developed by NEC for some of its Series 60 computers, as well as using certain printers, logic and memory manufactured by NEC. (DX 9415.)

(v) Melcom Business Systems, Inc., a U.S. subsidiary of Mitsubishi, markets the Melcom 80 small computer in the United States. (DX 9415; see Withington, Tr. 112917-18.) In addition, Mitsubishi markets peripherals on an OEM basis in the United States. (DX 9415.)

(vi) Toshiba markets its TOSBAC small computers in the United States through Toshiba America. It also markets consoles to Honeywell. (Id.)

(vii) Sharp, NPL and Oki also offer a variety of EDP products in the United States, including microprocessors, printers, card readers and IBM-plug-compatible disk drives. (Id.)

These represent only some examples of Japanese activity in the United States. (For other examples see DX 4904.) In the words of McCollister, these companies are "a competitive force to reckon with". (Tr. 9583.)

b. European Manufacturers. European computer manufacturers have also been coming out with state-of-the-art products and increasing their sales in the United States. Three are of particular note: Siemens AG, ICL Ltd., and Nixdorf Computer.

(i) Siemens AG. In 1975 Siemens was "the sixth largest company in the world in the field of electrical engineering". (DX 4904, ¶ 2.30.3.) In 1978 Siemens ranked Number 6 in the Fortune directory of the 500 largest industrial corporations outside the United States, with sales of over $13.8 billion. (DX 8053.) Its product line includes electrical power distribution equipment, communications systems, power cables, and semiconductor components and data and information systems. (DX 13911, p. 13.)

In the EDP area, Siemens manufactures semiconductors and memory components, microprocessors and small to very large computers and peripherals. (See DX 13911, pp. 14-17.) In 1979 Siemens' Data and Information Systems Group had sales of about $920 million and was the fastest growing group in Siemens. (See DX 14092, p. 16; DX 14097, p. 32.)

In the second half of the 1970s Siemens has increased its activity in the United States. In 1977, the Supervisory Board of Siemens stated that:

> "[C]apital investment plans were a major topic, particularly the plans for the further expansion of our business in the U.S.A." (DX 14091, p. 4.)

Siemens has a U.S. subsidiary called Siemens Corporation. (We shall refer to it as "Siemens-USA".) By fiscal 1979 that subsidiary had revenues of $408 million. (DX 14097, p. 2.) Siemens-USA reported a 39.5 percent increase in revenues for the first six months of fiscal 1980. (DX 14120.)

Siemens-USA's business includes a variety of semiconductor products, communications equipment and computer products. For example:

(a) In 1979 Siemens-USA began to market 16K memory chips along with its specialty semiconductor components, teleprinters and computer-controlled switching systems. (DX 14097, pp. 16, 22.)

(b) Also in 1979, Siemens-USA acquired the "mini-floppy" disk product line from Perkin-Elmer, which it now markets on an OEM basis. (DX 14097, p. 2.) In 1979 it was reported that Siemens had agreed to sell its laser printers, said to be similar to IBM's 3800 printer, to Univac on an OEM basis. (DX 14121.)

(c) Siemens-USA also manufactures an OEM disk line in the United States, which ranges in capacity up to 500 megabytes. (DX 14119; DX 14092, p. 2; DX 14377.)

(d) In 1979 Siemens-USA also entered into an agreement with Rockwell International "for product exchange and the distribution of magnetic bubble memories and their associated subsystems". (DX 14092, p. 15.)

(ii) <u>ICL, Limited.</u> ICL Limited was formed in England in 1968 out of a number of smaller computer companies. (See DX 4904, ¶ 14.1.3.) Since that time, ICL has grown steadily. ICL's sales in 1978 exceeded $956 million and the company ranked 338th in the 1978 Fortune directory of the 500 largest industrial corporations outside the United States. (DX 8053.)

ICL manufactures and markets a range of computer products, from small to very large systems. (See DX 14113.)

Since the early 1970s, ICL has made several investments and computer announcements that have broadened its product and marketing coverage:

(a) In 1975 ICL acquired a one-third interest in Computer Peripherals Inc., which, at the time, was jointly owned by CDC and NCR. (DX 14079, p. 5.)

(b) In 1976 ICL acquired Singer's foreign computer base and its marketing force, as well as certain of the U.S. manufacturing facilities of Cogar, a Singer subsidiary, which manufactures intelligent terminals. (DX 14080, pp. 5, 11, 25-26; DX 3331.) ICL described the anticipated effects of these acquisitions on its operations as follows:

> "The acquisition of the international operations of Singer Business Machines was the result of our wish to bring about a major and dramatic change in our ability to prosper in the world market. ICL now has the opportunity for profitable business in new markets in which we have not hitherto been active, and we have significantly increased the density of our computer population around the world. We have also brought some 3,000 people into ICL to enhance our customer service in the markets in which we already work. From October 1976, ICL is actively engaged in Italy, Spain, Norway and Finland where previously no ICL operations existed. In Latin America we are now operating in Mexico and Brazil, as well as through dealers in Venezuela, Peru and Argentina.
>
> "For several years ICL has been concentrating its efforts on increasing its overseas business. With our new employees, with our increased customer base and with the new markets in which we now operate, ICL is now established as a major force in the world computer industry." (DX 14080, p. 26.)

(c) In 1976 ICL introduced the ICL 2904 computer systems in the United States, which was claimed to offer a 50 percent increase in instruction-execution speed over its predecessor. (DX 14489.)

(d) In 1977 ICL began to offer the ICL 220 Series as a Singer System Ten upgrade. (DX 3323.) For that year, ICL reported that the 220 system and its predecessor accounted for sales of 36 million British pounds, 75 percent of which came from non-British business. According to ICL, "This order level was higher than anything achieved previously for this series of equipment." (DX 14081, p. 22.)

(e) In January 1980 ICL introduced the Model 320, which can be used as a stand-alone system or as part of a distributed network. The 320 will be manufactured in the United States. DX 14114.)

(f) In January 1980, ICL announced that it would begin to market its array processor and large configurations of ICL's 2900 Systems in the U.S. (DX 13242.)

(g) In June 1980, ICL announced it would market its recently-introduced ME 29 computer system in the United States. ME 29 can support one million bytes of main memory and up to 16 billion bytes of on-line disk storage. (DX 14115.)

(h) In addition, ICL continues to market the 1500 "expandable minicomputer" in the United States and the 9500 point-of-sale series of terminals. (DX 11727; DX 11633; DX 14392, pp. 30-32.)

(iii) <u>Nixdorf, AG.</u> Nixdorf Computer was founded in the

1950s, but achieved its most rapid growth in the 1970s: Nixdorf's revenues grew from $103 million in 1969 to $723 million in 1979. (DX 13893; DX 14414.) In its 1979 Annual Report, Nixdorf reported that it "develops, produces and markets electronic data processing systems for use in every size of company. The Group ranks among the leading international computer manufacturers with a customer base of over 70,000 installations." (DX 13893, p. 12.)

Nixdorf began marketing computer equipment in the United States in 1969 and has expanded its U.S. activities since that time. In 1977 Nixdorf acquired Entrex Corporation and integrated it into Nixdorf Computer Corp. (DX 14471, p.10.) Nixdorf's U.S. revenues have increased from $42 million in 1977 to over $100 million in 1979. (See DX 14471, p. 8; DX 13893, p. 42; DX 14414) and was ranked 55th in data processing revenues in 1979, by Datamation. (DX 13945.) Nixdorf has sales and maintenance offices in 110 cities in the United States. (See DX 11859.)

Nixdorf's product line in the U.S. includes a variety of systems and equipment. (See DX 12984; DX 12986, pp. 3, 7, 11; DX 12987, pp. 4-5, 7-8, 11.) Primarily, the products are marketed with an emphasis on distributed processing configurations. (DX 14471, p. 9.)

> "From its early years, the Company has been quick to seize on technological change to pioneer new departures in computer usage. It grasped the opportunity offered by the declining cost of high-performance technology to launch a range of computer systems, as early as the mid-Sixties, at a price/performance ratio that opened up new markets:

'the market of small- and medium-sized businesses. Nixdorf systems provided this group of users with the first opportunity of installing data processing systems, the market of large companies and organizations. These users were offered an alternative to large central processors in the form of smaller systems suitable for decentralized installations. This set a new precedent in the use of computers. Companies were no longer forced to adapt their organization to the computer but could tailor their EDP installations to suit their corporate structure.'

"Today, computer systems suitable for use in the small company as well as in the decentralized mode in the large organization have become an established feature in the market." (DX 14471, p. 25.)

In May 1980 Nixdorf announced that it would market in the U.S. and elsewhere an IBM 4331-compatible computer. At the same time, Nixdorf announced its acquisition of The Computer Software Company, which designs and markets IBM-compatible systems control programming. (DX 14118.)

VIII. IBM: 1975-1980

75. IBM Product and Pricing Actions. At the end of 1974, IBM was confronted with several developments:

First, the company, although still growing, was not growing as rapidly as the EDP industry as a whole and as a result IBM was losing position in relation to its competitors. By the beginning of 1973, based on the data collected in Census II from about 600 firms, IBM's percentage of EDP revenues in the United States had fallen to about 33 percent, from a percentage of about 49 percent in 1963. (DX 3811; DX 8224.) Looking at the domestic data processing revenues of only the top 50 firms in the industry, based on Datamation's estimates, IBM's domestic data processing revenues in 1976 represented about 44 percent of that total and would decline to 34 percent by 1979. (DX 13658; DX 13945.)*

Second, as we have detailed in the preceding portions of this testimony (pp. 981-1042, above), other suppliers in the industry were announcing and delivering many new and improved computer products and services. These offerings--judged by the success and growth of the firms supplying them--were obviously attractive to users of computer equipment of all kinds--including users of IBM's equipment.

Third, IBM was confronted by a greater number of competi-

* Datamation's methodology was discussed on p. 1068 above.

tors in the mid-1970s than at any previous time in its history in the computer business and by a greater variety of competitors, including:

(i) the systems competitors of the 1960s, such as Univac, Honeywell, CDC, DEC, NCR, Hewlett-Packard and Burroughs;

(ii) newer systems manufacturers, once called "minicomputer" makers, but which in the mid-1970s--whatever their label--were substantial manufacturers of competitive computer systems. These companies included such companies as Data General, Perkin-Elmer, Wang, Datapoint, as well as even newer companies like Prime and Tandem;

(iii) plug-compatible peripheral equipment manufacturers for virtually every box of peripheral equipment IBM was marketing, including disk subsystems, tape subsystems, printers, communications controllers, memory systems and terminals of all kinds, products which by the Seventies amounted to 70% or more of the value of computer systems;

(iv) plug-compatible processor manufacturers led by Amdahl and quickly joined by National Semiconductor, Fujitsu, Hitachi, Magnuson and others--all of which were marketing box-for-box replacements for what traditionally had been the "heart" of IBM's computer systems line;

(v) leasing companies which were offering System/370 equipment as well as System/360 equipment on a variety of terms and with a variety of plug-compatible equipment; and

(vi) service bureau and time-sharing suppliers which had been increasing the sophistication and variety of their service and software offerings and had themselves begun to offer advanced computer hardware.

Fourth, the IBM System/370 equipment which had been announced in the first three years of the 1970s to replace System/360 was itself facing stiffer competition from the newer products and services being announced by competitors.

People within IBM were aware of the competitive forces affecting the company in 1974 and 1975. Defendant's Exhibit 9404, for example, is a document prepared by IBM's Commercial Analysis department in the Data Processing Division, for V.J. Goldberg, who was then Assistant Group Executive of the Data Processing Marketing Group. The document is dated November 1975, and contains "an outline of the current market environment and related Competitive Activity". (DX 9404, p. 1.)

What follows are pages 2 through 5 and 7 of the document:

1975 MARKETPLACE ENVIRONMENT

MANAGEMENT INFORMATION SYSTEMS

- Growth of DB/DC
- Requirement for larger systems and larger storage
- Demand for easier installation and adaptibility to end user needs
- Emergence of device independent networking[1]

DISTRIBUTED COMPUTING

- Availability of low cost, remote intelligence
- Increase in small minisystems/terminals at remote sites
- Growth in autotransaction[2]
- Distributed data base and intelligence[3]
- Stand-alone departmental computers

OFFLOADING - CYCLE STEALING FROM HOST

- Communication front-end processors/regional concentrators
- Intelligent terminals[4]
- Data entry[4]
- Minisystem stand-alone applications

MAJOR TRENDS

- Shift toward purchase
- Alternative solutions: Minisystem stand-alone applications
  Distributed processing
- Emphasis on non-traditional systems approaches

1975 MAJOR COMPETITIVE OFFERINGS

- Minisytems
- Wide variety of data entry/terminal products[5]
- Multi-vendor networking[6]
- Software compatible processors[7]
- Enhanced time-sharing products and services[8]
- Competitive independent peripherals
- Continued third party activity
- Traditional competitors shift to distributed processing

FOOTNOTES

1. Device independent networks will allow diverse terminals and processors, manufactured by different vendors, to communicate with one another using standardized network protocols.

2. Autotransaction is a term used to describe data processing tasks generated by event driven terminal devices which are used for one or a limited number of applications. Some examples are POS, Teller Terminals, Airline Reservation Systems, Brokerage Terminals.

3. Distributed Data Base is an extension to Distributed Computing where the remote computer has its own data base. The addition of 3330-like files to minisystems makes this a practical alternative for positioning "local" data.

4. Offloading by intelligent terminals and data entry devices can take two forms. In one case the device can process data that would normally be processed by the host and transmit summary data only. In the second case the remote device does all processing and little or no data is transmitted to the host.

5. The distinction between terminal and data entry products is disappearing as both acquire intelligence through embedded minisystems. However, there is expected to be a profusion of device types, many limited to specific applications.

6. It is anticipated that many of the networks will be developed to encompass a variety of hardware from different manufacturers. Moreover, the networks will be used to communicate among terminals and processors produced by different vendors.

7. The Japanese, both through Amdahl, and with their own M and V Series, represent the greatest threat. However, should this approach be successful we can expect some of our domestic competitors to market IBM compatible systems.

8. Enhanced timesharing encompasses not only competitive offerings for in-house timesharing (e.g. DEC System 10 and minisystems) but also enhancements to competitive data servicer offerings (e.g. CDC Cybernet).

1975 COMPETITIVE ACTIVITY

SYSTEMS

LARGE SYSTEMS

- DB/DC Emphasis
- Networking
- Large scientific environment
- IBM software compatible

Impact on IBM: Software compatible is major threat

INTERMEDIATE SYSTEMS

- Recent announcements upgrade to third generation
- DB/DC growth
- Stress price/performance
- S/370 joins S/360 as third party competitor

Impact on IBM: Increasing competitive pressure head to head
Principal competitor still third party

MINISYSTEMS

- Continued improvement in price performance
- System size ranges from micro to large
- Trend toward communications/terminal offerings
- Ease of use and installation
- Systems integrators increase in industry oriented products

Impact on IBM: System off-load impacts large and intermediate
Direct competition with intermediate systems
Alternatives to IBM VS and SNA strategy
Represent customer purchase commitments

1975 COMPETITIVE ACTIVITY

INDEPENDENT PERIPHERALS

- Continued growth in installed base despite replacement of older models

- Continue to follow IBM lead - except in VS exclusivity

- Diversification through multiple product offerings, trend to package deals

- Pursue OEM sales to expand potential

Impact on IBM: Continued competitive pressure
Attachment to non-VS & S/360 alternatives

IBM CONFIDENTIAL

1975 COMPETITIVE ACTIVITY

SOFTWARE

- Intelligent terminals have stand-alone capability
  - Cobol
  - RPG
  - Basic

- Minisystems continue to increase their commercial capability
  - Operating System
  - Cobol
  - DB/DC

- Networking support being provided by manufacturers and integrators of minisystems and controllers

- Competitive DB/DC products stress ease-of-use and support many OEM devices

- Enhanced timesharing software available on minisystems and other systems

<u>Impact on IBM:</u> Improved software capability strengthens distributed processing and off-loads the host

Minisystem function approaches intermediate systems at a much lower cost

An important trend which appears throughout this outline is the competitive impact on IBM of "minisystems", "remote intelligence", "intelligent terminals" and "offloading--cycle stealing from host". These were viewed as "alternative solutions" to the traditional IBM approach and competition to IBM's intermediate and large systems. The document further noted the "shift" by "[t]raditional competitors . . . to distributed processing".

This "outline" is only one of many internal IBM documents that recognized the pervasive effect that "minisystems" and distributed processing developments were having on IBM's entire computer business. For example, in 1973, Ralph Pfeiffer, Jr., then President of IBM's Data Processing Division, wrote to his superior, Dean McKay, IBM Vice President and Group Executive of the DP Marketing Group, reflecting a "growing concern regarding the impact of minicomputers". (DX 9396, p. 1.) The attachment to his memorandum reads in part:

> "The minicomputer has emerged from its traditional role as the small OEM processor and has developed into a full-function, low-price entry, general-purpose computing system, spanning a variety of application areas, such as:
>
> "- Stand-alone processors (business and scientific systems)
>
> "- Telecommunications (including multiplexors, line concentrators, RJE terminals)
>
> "- Time sharing systems
>
> "- Sensor-based systems
>
> "- Peripheral processors/controllers
>
> "The economy of scale favoring large scale computers is disappearing." (Id., p. 2.)

The memorandum notes: "The distributive and/or decentralized computing strategy underlying minicomputers is in direct contrast with IBM's centralized systems approach." (Id., p. 3.) In 1973 and 1974, to be sure, IBM offered a variety of products for use in on-line systems, which included remote--distributed--equipment. IBM's terminal products like the 3270 are examples. (See pp. 974-75, above.) IBM also offered System/3 and System/7 equipment that could be used to perform remote processing on-line as part of larger 370 systems and, of course, IBM's 370 processors were also used in this way. (See pp. 1060, 1359, 1459 above.) But one of IBM marketing approaches at this time focused on the belief that users desired centralized control of programming and centralized location of processing and storage.

As we have discussed earlier, changing costs of memory and logic and the desire of many users to bring computing power to the source of the data were leading to greater use of smaller processors. The Pfeiffer memorandum makes the point not only that the "economy of scale favoring large scale computers is disappearing", but also that there are other very "significant advantages" to distributed or decentralized configurations of equipment,

> "such as multiple processor flexibility, less down-time risk because of back-up availability, functional specialization, faster system implementation on a step-by-step basis, providing quicker pay-back and modular expansion." (Id., p. 3.)

That same year, 1973, a task force in IBM's DP Marketing Group--the "Higgins Task Force"--came to roughly the same conclusions about "minicomputers" and distributed or decentralized processing. The task force made a presentation to "Group and Corporate Management", and to Akers, who at the time was President of the Data Processing Division. (Akers, Tr. 96799-802; DX 9400, p. 1.) The task force addressed the issue of "minisystems", and called it a "serious problem--effects [sic] all products". (DX 9400, p. R4.)

The 1973 presentation noted that "minisystems are low cost computers that compete with IBM System/3 Mod 6 through System/370" and that they "are becoming an effective alternate solution to many end-user requirements". (Id., pp. R7, R37.) The report also estimated that "minicomputer [manufacturers] will be shipping as much computing power as IBM by 1973-1974" and "[b]y 1976, computing power of installed minicomputers will equal that of IBM". (Id., p. R22.)

The presentation's conclusion was both that "greater knowledge" was needed and that IBM "needed product alternatives". (Id., p. 55.)

These presentations recognized that competitive "minicomputers" were affecting not only IBM's smaller systems sales, but more fundamentally, that the availability of smaller, sophisticated computers were expanding the equipment and systems choices for general purpose computer systems and hence, were affecting IBM's entire computer product line. The traditional notion of a "central" processor of the 1950s and 1960s was only one of many alternative configurations for getting the data processing jobs done.

As we have just discussed, this point was brought home to many IBM executives in the 1973-75 time frame. It was also underscored in IBM development plans with respect to its very largest processors. During the course of reviewing IBM's product needs, a task force surveyed 119 of IBM's large customers. (Akers, Tr. 96873-74, 96886.)* In assessing the competitiveness of IBM's current and planned largest processors, one of the findings of the survey was: "64% of [the] sample [of customers] considering offloading now". (DX 9399, p. 12.) Akers testified about this finding:

> "The page is entitled 'Alternatives,' and talks about offloading.
>
> "Let me explain what 'offloading' means.
>
> "A user of a computer system in executing work on that computer system considers from time to time taking some of that work from that computer system and doing it in an alternative way.
>
> "In the presentation that is being given to me in 1975 and as we are reviewing here today, this discusses plans on the part of some of our customers to take work that they were currently performing on large processors and offloading it or taking it off those processors and performing that work with multiple small processors.
>
> "As I indicated earlier, the DP staff had done considerable research with more than one hundred customers in order to be as articulate as they could regarding the requirements for our large processor plans.
>
> "As a result of their visits with those one hundred cus-

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* Examples of the individual accounts reviewed in the document are discussed on pp. 1308-10, below.)

tomers--one hundred nineteen, to be exact--they found that 64%--and that's what the bar on the left indicates above the 'Yes'--were currently considering offloading as I have just defined offloading and they have listed here in some detail individual customer situations and their plans or considerations for offloading and, further, indicate the types of offloading are new applications that currently are not on those central site processors, the removing of workload from the processors to the communications controllers, and that's what 'front-ending' means or, as I indicated earlier, the decentralization or the removal of some or all of the applications that were being performed on those large processors as part of those plans.

"The net of all that is that two-thirds of one hundred of the largest users of IBM's large processors were actively considering alternatives to doing their work other than with large processors, and that's the net of this page." (Tr. 96886-87.)

In the years 1975 to the present, IBM introduced new products in every part of its computer product line, including new processors, memory, disk and tape storage subsystems, terminal subsystems, printing devices, mass storage devices as well as a variety of program products. And during these same years, IBM also was forced to reduce its prices again and again. One industry observer referred to "the river of new product announcements" from IBM as well as other competitors in 1977 and stated:

"Led by a flood of IBM announcements it is probable that 1977 will see more, significant new product moves than at any time since the halcyon days of the mid-1960s." (DX 12266, p. 8.)

As a result of its announcements IBM did in fact replace its System/370 line as it existed in 1974; by 1979 "80 percent or more" of the revenue of IBM's Data Processing Division came from products that "were begun in manufacture since 1974". (Akers, Tr. 96932.)

We shall discuss some of the IBM price and product action in the 1975-1980 years.

a. System/32. In January 1975, IBM announced the System 32, a very low cost general purpose computer system. (DX 9402, p. 36; DX 13378.)

As announced, a System/32 could be rented for as little a: $809 per month (DX 13378, p. 4), compared with an "entry" level System/3 rental of about $1,000 per month (DX 8073, p. 3), and a small System/360 Model 20 rental of about $1,700 per month. (JX 38, p. 298.) For that low price, however, the equipment and programming were quite sophisticated. For example:

(i) The processor in the System/32, as announced, was capable of supporting up to 32,000 bytes of main memory. (DX 13378, p. 1.) By comparison, as announced, the System/360 Model 20 was capable of supporting only about 16,000 bytes of memory. (DX 2080, p. 3.)

(ii) The System/32 memory was made of the FET semiconductor memory IBM used in its larger processors. (E. Bloch, Tr. 91543-44; see also DX 13378, p. 1.)

(iii) Storage for the System/32, as announced, was availabl through non-removable disk drives with a capacity of up to 9.1 megabytes and through removable diskette drives, each of which could store up to approximately 250,000 bytes. (DX 13378, p. 4; see also G. Brown, Tr. 53350.)

(iv) Both line and serial printing equipment were announced to perform output on the System/32. Input could be performed via diskettes, the keyboard of the operator console, or cards. (DX 9402, p. 36; see also DX 13378, pp. 1-2.)

(v) In addition, IBM announced new systems control programming, called System/32 Operation Control Language (DX 9402, p. 38), as well as a number of separately priced standard applications programming products. (DX 14304, p. 1; DX 14424, p. 1; DX 14425, p. 1; DX 14423, p. 1; DX 14300, p. 1.)

The low cost and ease of use, including programming packages, of the System/32 made the equipment immediately attractive to smaller businesses, possibly the reason such systems are sometimes called "small business" computer systems. (Withington, Tr. 56398.) These systems were also marketed to individual locations within much larger enterprises, to perform processing at such locations as opposed to performing it at the enterprises' central complexes of computer equipment. (O'Neill, Tr. 76115-20; see also Case, Tr. 74160-61.)

The System/32 was quickly enhanced by IBM. For example:

(i) Between June and September of 1975, IBM offered additional applications packages for a variety of distribution industries, such as the appliances, plumbing/heating, paint/chemical and tobacco industries. (DX 14422; DX 14303.)

(ii) In January 1976, IBM announced enhanced disk storage for the System/32 by offering five new models, each providing 13.7 million bytes of non-removable disk storage--a disk capacity increase of more than 50%. (DX 14440.)

(iii) In June 1976, IBM announced nine new, low-cost model: of System/32 "featuring reduced disk capacity and/or slower printing speed"--"configurations which may better meet certain customer's processing requirements." (DX 14439, p. 1.) These new models were "fully field upgradable and compatible" with other System/32 models. (Id.)

In June and July of 1975, only about six months after the initial System/32 announcement, IBM announced software control programming which permitted the System/32 to function on-line as a remote job entry "work station" in a larger computer system which included an IBM 370 processor. (DX 14301; DX 14302.) With this capability, System/32 equipment could be used as part of "distribute data processing" system configurations, with diverse types of proces ing, storage, input/output and control products, situated in multiple locations--all functioning as a single computer system.

In April 1977, IBM announced the System/34, "a compatible follow-on to the highly successful System/32". (DX 13381, p. 1.) Like the System/32, the System/34 was physically compact, easy to install and operate, and supported by various industry application programs. In addition, the System/34 had the capacity for multi-programming, as well as the capability of communicating with other systems or devices at other locations. (DX 9402, p. 43; see also DX 13381, pp. 1-2.) The System/34 featured a disk capacity of 27.1

million bytes, as announced, nearly twice as much as the enhanced System/32, and also offered twice the memory available for the System/32: 64,000 bytes as compared to about 32,000 bytes. (DX 9402, pp. 74-76; DX 13378, pp. 1, 2; DX 13381, p. 2.)

System/34 was, according to IBM, well suited for distributed data processing needs. An IBM manual told the sales force that "[t]he flexibility of System/34, batch plus interactive processing concurrent with communications to a larger system . . . is a significant feature . . . . System/34 can be cost effective when utilized for distributed processing with concurrent communications." (DX 9402, p. 48.)

By 1978, System/32 and 34 equipment was being marketed by IBM and installed by customers for many "distributed data processing" system configurations. For example, some of the customers who had ordered or installed System/32 or System/34 equipment by 1978 were:

(i) American Airlines, for accounts receivable processing at two locations of its Sky Chefs catering subsidiary (O'Neill, Tr. 76115-17, see pp. 1395-96);

(ii) Foremost-McKesson, a drug wholesaler, for its ordering process;

(iii) Penn & Quill, Griswold's, and Sir Francis Drake, hotels and motels, for front office applications, including check-in and room availability and assignment;

(iv) Texas Commerce Bank and Northwest Computer Services, for capturing and processing MICR-coded documents nearer their sources for later posting at a central site;

(v) Manufacturers Hanover Trust, for international banking services, such as letters of credit, foreign exchange, and general ledger accounting;

(vi) First Federal Savings and Loan, in Jacksonville, Florida, for fixed asset accounting to produce reports for depreciation and tax schedules;

(vii) The Occupational Safety and Health Review Commission for docket tracking of administrative agency actions;

(viii) Walson Army Hospital at Fort Dix, New Jersey, for it outpatient pharmacy system, label printing, updating, inventor and drug interaction checking and warnings;

(ix) Fort Meade, for facilities engineering inventory control, including inventory issues and receipts, demand tracking, job costing, reorder point determination, and economic order quantity;

(x) The Veterans Administration, for purchase order writing and storing such standard information as "ship-to-address" or "terms and conditions" in the computer to eliminate needless manual effort; and

(xi) The Smithsonian Institute, for mail order services, credit-checking, for printing invoices, reports, inventory, sales analysis, and other pertinent data. (DX 9402, pp. 113-14, 147-51, 156-58, 163-69, 178-80, 461-62, 465-70, 476-77.)

b. IBM 3800 Printing Subsystem. In April 1975, a few months after the initial System/32 announcement, IBM moved to improve the printer product offerings for its System/370 processors larger than the 135. In that month, IBM announced the 3800 printing subsystem. (DX 9405, pp. 121-28.)

According to IBM's announcement, the 3800 "is a high-speed, non-impact, general purpose printer . . . us[ing] electro-photographic and laser technology". (DX 9405, p. 121.) In the 3800, a laser beam is used to replace the traditional mechanical parts used to form the characters in IBM's "chain" and "train" mechanical impact printers, the IBM 1403 and 3211 series. Using these newer, non-mechanical technologies, IBM was able to offer printing rates of up to 13,360 lines per minute (id.)--over six times the speed of IBM's fastest printer at that time, the 3211, announced with System/370 in 1970 and capable of printing about 2,000 lines per minute. (See p. 967, above.)

When introduced, the 3800 was the fastest on-line computer printer available. (Case, Tr. 72883.) Moreover, the 3800 subsystem was designed to include sufficient processing and storage capability within the printing subsystem to permit users to control and vary printing type styles, print sizes and forms. (Case, Tr. 72884, 72887.)*

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* Welch of the Chemical Bank testified that because of that capability within the 3800 "there is less need for the central processing unit . . . to use up its time in performing . . . at least some activities relative to printing." (Tr. 75102.)

In the year immediately following the 3800 announcement, IBM announced an increase in the 3800's maximum printing speed to 20,040 lines per minute. (DX 9405, pp. 479-80.) With this increas IBM was able to offer printing over 130 times faster than the IBM 716 printer used on the IBM 701 computer (150 lines per minute) at only about 4.0 times the purchase price--i.e., $310,000 for the 3800, as compared with $78,050 for the IBM 716 in 1957. (Case, Tr. 72879-84; PX 4714, p. 3; DX 3617; DX 9405, pp. 121-22, 128, 479-80; DX 8955, p. 1; Plaintiff's Admissions, Set II, ¶ 931.1.)* A report which would have taken 10 hours for an IBM computer to produce 20 years ago could be printed by the 3800 in less than 5 minutes. (See Case, Tr. 72879-81.)

In 1975, the 3800 was not the only non-impact printer on the market. For example:

(i) Honeywell had announced its PPS (Page Printing System) in 1974. The PPS was an electrostatic printer capable of printing up to 18,000 lines per minute. (DX 134; DX 11621.) However, it could not operate "on-line", required certain tape input and had to be used with Honeywell-supplied electrographi paper. (Spangle, Tr. 5309-13, 5315-16; Welch, Tr. 75256; DX 134, pp. 3, 5.)

(ii) In 1973, Xerox had announced its 1200 printer (DX 13407, p. 20), which could print 4,000 lines per minute via a

* This should be compared to the price levels for producers' durable goods generally which from 1952 to the mid-1970s rose by a factor of more than two and one-half. (See p. 1522, below.)

non-laser electrophotographic process. (G. Brown, Tr. 53230-31; DX 4901, p. 5.)

In mid-1977, two years after the announcement of the 3800, Xerox announced its Model 9700 printer, capable of printing 18,000 lines per minute using a non-impact electrophotographic-laser technology and representing a substantial speed improvement over the Xerox 1200. (DX 13407, pp. 6, 20; DX 12090.) The 9700 could be attached to the processors of various manufacturers. For example:

(i) Welch testified that Chemical Bank "active[ly]" considered the 9700 (as well as the Honeywell PPS) in competition with the IBM 3800 for attachment to the Bank's IBM-manufactured 370/168 and 158 central processing units. (Tr. 74980-82, 75256.)

(ii) In January 1979, it was reported that Burroughs had agreed to purchase up to $30 million of Model 9700 printers from Xerox for marketing with Burroughs' medium and large-scale computer systems. (DX 14234.)

At about the time of the Xerox 9700 announcement, Siemens AG introduced its ND-2 non-impact printer, which offered printing speeds up to 21,000 lines per minute. (DX 11961; DX 2597, p. 7; see also DX 11960.) This printer was marketed in competition with the IBM 3800 overseas and in the United States. (Akers, Tr. 97029.)

c. <u>IBM 3350/3344 Disk Systems.</u> In July 1975, IBM made two major announcements in its disk storage subsystems. Two years earlier, IBM's "Iceberg" and "Winchester" disk announcements had put IBM ahead of most, if not all, of its disk competitors at that time. (See pp. 1055-56 above.) The 3330 Model 11, "Iceberg", doubled the storage capacity of IBM's 3330 disk drive, announced in 1970, and the 3340, "Winchester", introduced new, highly innovative head/disk assembly packaging in a lower capacity, lower priced disk subsystem. Then, in September 1974 and May 1975 IBM announced attachment features that would permit use of the 3340 disk drives with IBM's System/3 and System/7 product lines, which enhanced the storage capabilities of those systems. (Welch, Tr. 74936; DX 14336; DX 14337.)

In the twenty-four months following the 3330 Model 11 and 3340 announcements, however, numerous competitive disk announcements were made. For example:

(i) In July 1973 CalComp announced a disk storage system, which was marketed as media compatible with the IBM 3330 Model 11. (G. Brown, Tr. 52099-100, 52105, 52159-60; DX 2377A.)

(ii) In October 1973, Memorex announced a disk drive, said to be plug- and media-compatible with the IBM 3330 Model 11. (Gardner, Tr. 36992-93; G. Brown, Tr. 52099-100, 52159-60; DX 2377A.)

(iii) Also in October 1973, STC announced the first of its Super Disks, "a box . . . that has four stacks of disk packs, and . . . one centralized actuator . . . . [T]he effect . . . was to have under one cover in one box 800 megabytes of information stored." (Aweida, Tr. 49342.) The Super Disk thus offered in one cabinet, twice the storage available in one 3330 Model 11 two-spindle box. (PX 4701, p. 31; see DX 10647, p. 14.)

(iv) In January 1974 Memorex announced the new 3673 controller, making its 3330-type disk systems directly attachable to the IBM System/370 Models 125 and 135 integrated controls, and in October 1974 Memorex expanded the function of the 3673 to include attachment to the ISC of the System/370 Models 145, 158 and 168. (DX 13310; see also DX 11770; DX 11771.)

(v) In February 1974, Univac introduced an IBM 3330 equivalent disk drive manufactured by ISS, designed for use with Univac's 90/60 and 90/70 systems. (DX 1493; DX 13329.)

(vi) In March 1974, CDC announced a double density 3330-type disk drive for attachment to IBM System/370 and larger models of System/360. (DX 13260; see G. Brown, Tr. 52099-100; DX 2377A.) CDC reportedly included a high capacity double density disk subsystem in its CYBER 170 System, also announced in April 1974. (DX 13261.)

During these months, IBM continued its development efforts and in the summer of 1975, announced a series of price and product actions.

First, on July 1, 1975, IBM reduced the purchase prices on its Model 2319, 3330, 3330 Model 11 and 3340 disk drives by 10 percent. (DX 9405, pp. 143-47.)

Second, two weeks later, IBM announced two new disk storage products, the 3350 and the 3344 ("Madrid") disk drives. (PX 4540; see Haughton, Tr. 94943-47.) These drives were attachabl to System/370 processors through IBM's existing control units and integrated controllers. (PX 4540, pp. 1, 3.)

The 3350 offered significant improvements in price/perfor mance over IBM's earlier disk products, including the 3330 Model 11 For example:

(i) The 3350 provided 635 megabytes of storage per two-spindle box, allowing more than 2.5 billion bytes of storage per string of disk drives, compared to a capacity of 400 million bytes per two-spindle box and 1.6 billion bytes per strin on the 3330 Model 11. (PX 4539, p. 1; PX 4540, p. 1.)

(ii) Data could be transferred from the 3350 to a CPU at the rate of almost 1.2 million bytes per second (PX 4540, p. 1), approximately 50% faster than the 3330 and 3330 Model 11. (Case, Tr. 72737-48; DX 3554D.)

(iii) One dollar of monthly rental bought 470,000 bytes of storage on the 3350, as compared with 207,200 bytes on the 3330 Model 11, and 145,600 bytes on the 3330. (PX 4539; DX 1437, pp. 1, 3; DX 9405, pp. 174, 178; see Withington, Tr. 58455-56; Haughton, Tr. 94952.)

Taking a somewhat broader time perspective, Dr. Haughton of IBM testified that the 3350 represented a 1500-fold increase in areal density, measured in bits per square inch, over the first IBM disk drive, introduced only 19 years earlier. This rapid advancement in recording density was coupled with a 136-fold increase in data rate and a 24-fold decrease in average access time. (Tr. 94996, 94999; see also Case, Tr. 72739, 72747; DX 3554D; DX 9361B.)

These improvements are difficult to put into perspective. Welch of Chemical Bank, however, described the storage capacity and speed of the 3350 by explaining that on four of them he could store the entire content of 18,000 500-page novels and could retrieve any word in the novels in an average of 25 milliseconds. (Tr. 74858.) He also stated that the entire disk storage requirement for American Airlines, as of 1972, could fit on three 3350s, as compared to the twenty 2314s American actually had installed at that time. (Tr. 74858-59; see Tr. 74732-33.)

The 3344, which was compatible with the 3340 "Winchester" (Haughton, Tr. 94946), attached to a standard 3340 in a string combination. It represented a growth option for 3340 users because of its significant improvements over the 3340, especially in terms of capacity. The 3344, available for use on System/370 Models 135 and above, featured a capacity of approximately 280 megabytes per spindle, with a maximum configuration of more than 1.8 billion bytes per 3340/3344 string, as compared with approximately 70 megabytes per spindle and 560 million bytes per string for the 3340 (with 3348 Model 70 Data Modules). (PX 4538, pp. 1, 3; PX 4540, p. 3.)

With the 3350 IBM came full cycle, returning to the fixed disk file design which had existed prior to IBM's introduction of the industry's first removable disk pack, announced in 1962 with the IBM 1311 disk subsystem. (See p. 152 above.) The removability feature had been highly attractive to computer users because it enabled them to store disk packs and transfer them from one drive to another, the way magnetic tapes were stored and moved. (See Withington, Tr. 56247-48; Case, Tr. 72806-07; Haughton, Tr. 94864.) Removability and interchangeability, however, entailed substantial engineering and manufacturing problems (see p. 153 above), since rigorous manufacturing tolerances were required, particularly at the high recording densities being achieved on disk packs by the mid-1970s. (See Haughton, Tr. 94921-22.)

The 3340 "Winchester" data module approach had reduced a number of problems associated with removability and interchangeability, by keeping the disks and read/write heads together in one sealed pack. (See pp. 1055-56 above.) But there was "still progres to be had with a fixed disk drive". (Haughton, Tr. 94942; see Tr. 94920-21.) The "fixed file" design, used in the 3350 and 3344, reduced the manufacturing tolerance problems associated with removability and interchangeability and permitted increased recording densities to be achieved at reduced costs. (Case, Tr. 72748; Haughton, Tr. 94949-53, 94995-007; DX 9361B.) Hence, in contrast to earlier IBM drives, the 3350 and 3344 integrated the head-disk assemblies which then were "not designed for customer handling". (Haughton, Tr. 94983; see Tr. 94981.) With the 3350 disk drive, IBM offered sufficient storage capacity on a single disk drive to make removability unnecessary for most users. (Case, Tr. 72747-48.) According to Haughton, "[b]y 1975 . . . [IBM] had done some surveys at that time that showed that in many cases people weren't taking the disks off. By that time we felt that a mixture of fixed and removable [disks] was very appropriate . . . ." (Tr. 94943.) In fact, an IBM study conducted in 1972 observed:

> "The customer receptivity to the fixed file concept was overwhelming. Only two users (5.7% of the sample) stated that they would not consider fixed files. The other all indicated that they could go to fixed files for part of their DASD operations, with 7 of them (20% of the sample) indicating they could go to 100% fixed files. The sample indicates that, under the proper conditions, 62.5% of the DASD spindles could be fixed."

And:

> "[T]he trend in number of packs per spindle is decreasing very rapidly, notably among the 3330 users where the pack/spindle ratio is 1.2 to 1." (PX 5305, pp. R6, R14.)

Despite the advances in technology and price represented by the IBM 3350 and 3344 drives, IBM's competitors began to respond quickly. By the spring of 1977, IBM analysts in the DPD Commercial Analysis department reached these conclusions about IBM's competitive disk position: The "major system manufacturers" were offering a "price differential [of] about 5%" for 3330-type drives and were announcing "3350-types"; the PCM disk competitors were offering "price differentials up to 50% for 3330-types (new lease)" and were beginning "early installations" of their 3340 and 3350-types. (DX 9413, p. 19.)*

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* The review also concluded that in "low end" disk systems, there was a "trend toward high capacity". (Id.)

In April 1977, IBM again reduced the purchase prices of its 3330 and 3330 Model 11, this time by about 15%. (DX 9405, p. 579.)

d. IBM 5100 Computer System. In September 1975, IBM announced the 5100. (DX 13379, p. 1.) The 5100 was a portable "desk top" computer system, weighing 50 pounds, and was described by IBM in its announcement letter as "combining the compactness of a desk-top unit with the function of a stand-alone computer". (Id.) The 5100 featured:

(i) FET memory expandable from 16,000 to 64,000 bytes--equivalent to the maximum memory capacity available on IBM's System/360 Model 30; however, the 5100 system's purchase price was only five times what it cost to rent a similar configuration of a Model 30 processor for one month (JX 38, p. 33; DX 13379, pp. 1, 5);

(ii) APL and BASIC programming languages;

(iii) a 1024-character CRT screen for output;

(iv) an optional 80 character per second printer; and

(v) an optional auxiliary tape unit. (DX 13379, p. 1.)

At announcement, the 5100 had a purchase price of under $9,000, for a minimum configuration, to approximately $27,000, when configured with full 64K memory, printer, tape unit, and I/O adapter. (DX 13379, pp. 5-6.)

IBM introduced the 5110 in January 1978, and the 5120 in February 1980. (DX 14306, p. 1; DX 14307, p. 1.) Each of these newer systems retained the "desk top" design of the 5100, despite the increased capabilities each offered over the 5100. (DX 13379, p. 1; DX 14306, pp. 1, 2; DX 14307, p. 1.) For example, the 5110 was described by IBM in its announcement letter as "designed to address a wide variety of commercial and problem solving applications in both the small and large business" and offered a new diskette storage device with a maximum capacity of 4.8 million bytes. (DX 14306, pp. 1-2.)

IBM supported the 5100/5110/5120 series of computers with a variety of applications programs, including: project control, business planning, business report and application development, construction payroll, labor costing, linear programming, international airfreight rating, general ledger, fixed asset accounting and control, general accounting, inventory reporting, administrative control, and dealer parts inventory. (DX 9401, p. 111; DX 14299, p. 1; DX 14438, p. 1; DX 14298, p. 1; DX 14437, p. 1; DX 14436, p. 1; DX 14435, p. 1; DX 14434, p. 1; DX 14433, p. 1; DX 14432, p. 1.)

The 5100 "family" provided users with very low cost systems capable of a range of different applications. With the computers, significant computing capability could be brought to desktops. In 1978, an IBM guide to the sales force explained that:

> "The IBM 5110 computing system is designed to address a wide variety of application needs of the small business and the remote processing requirements of the large firm". (DX 9401, p. 24.)

Also, by that time, the 5110 was equipped to operate as a "complete standalone system that can communicate with a host when required" and could "compete with time sharing applications that are not significantly computer bound". (Id.)

Introducing the 5100 "family" necessarily meant that some processing that otherwise could be performed on IBM's existing 370 line, through, for example, time-sharing software and a combination of 370 processors, "dumb" terminals and other peripheral equipment, could now be performed by this "desk top" alternative. And in fact that is what happened. For example:

(i) Chemical Bank acquired a 5110 for tracking fixed assets, an application the bank had considered performing through use of an installed 370/168, 158 or 138 processor. (Welch, Tr. 75197-200.)

(ii) American Airlines used a 5100 to perform travel agent accounting and travel agent receivable applications and a 5110 to perform "a variety of tasks", including maintenance and engineering problem solving. (O'Neill, Tr. 76077-78, 76151.) In 1978, American Airlines was examining the possibility of adding to installed 5100 and 5110 equipment work that was then being done by American's 370/168s and Amdahl 470/V-6 processors and peripheral equipment as "a reasonable alternative to adding more capacity to the 370/168s and the 470/V-6". (Tr. 76078.)

(iii) American Airlines also used a 5100 for part of its time-sharing applications (Tr. 76077), the type that was performed by American's IBM 370/168 or its Amdahl 470/V-6 or by service bureaus. (Tr. 76102-03.) The time-sharing user at a terminal

> "perceives that he has all the processing capability at his disposal at any given time. He has that perception whether he is using a 370/168 or a 470/V6. . . . He has that perception whether he is using a service bureau, and he has that perception whether he is using a 5100 or a 5110." (Tr. 76103.)

The pressure from the "[a]vailability of low cost, remote intelligence" offered by others and the "off-load impacts [on] large and intermediate" systems, however, made the offering of such systems as the 5100 family necessary, if IBM was to meet the newer competitive environment of the 1970s. (DX 9404, pp. 2, 4.)

e. Attached Processors: 168 and 158. In February and October 1976, IBM made announcements that significantly improved the attractiveness and the price/performance of its then largest 370 processors, the 168 and 158. Announced in 1972, those processors were among IBM's most successful products.

From 1972 through 1975, IBM had already improved the performance of these large processors. For example:

(i) In February 1973, even before volume shipments of the 158 and 168 processors had begun, IBM announced "multiprocessor" configurations of the 158/168, which permitted the use of multiple processors in such a way that all of the processors and associated peripherals operate as part of a single computer system in which scheduling and control is provided as if there were a single CPU rather than multiple CPUs. (DX 14441.)*

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* The multiprocessor system, in a "tightly coupled" configuration--where individual CPUs are connected by an IBM 3068 or 3058

(ii) In March 1975, IBM announced the 168-3 and 158-3 processors which, with identical configurations and programming, were in the range of 5 to 13 percent faster than the earlier 168/158s. (DX 9405, pp. 114-120.)

By late 1975, however, these improvements no longer appeared to be enough.

It was also in late 1975 that Akers received the presentation on "Large Systems Product Plans" which we have already discussed. (DX 9399; see pp. 1506-10 below.) At the time, Akers was President of IBM's Data Processing Division. (DX 9397, p. 3.) The presentation was made by Akers' systems marketing staff "regarding their perspective of the product plans for large systems, large processors". (Tr. 96873.) At the time of the presentation, "Lexington", one of the products assessed in the presentation, was the code name for what became the "attached processor" or "AP" for the IBM 168 ultimately announced in February 1976. (Akers, Tr. 96876; DX 9405, p. 287.)*

Multisystem Communication Unit--featured two processing units sharing their combined main storage and operating under a single system control program. In a "loosely coupled" configuration--where the processors generally are connected by channel to channel communications--each processor has its own main storage and operates its own system control program. (DX 14441 .)

* The other large processors discussed in the Large Systems presentation were the 3033 (168I), announced in March 1977; the 3033AP (168I + AU), announced in January 1979, and the 3033MP (168I MP), announced in March 1978. (Akers, Tr. 96879-82; DX 9405, pp. 553, 743, 1006.)

There were a number of concerns expressed during this presentation:

<u>First</u>, despite IBM's various 158/168 enhancements and the fact that "RAS", meaning reliability, availability, and serviceability, for the 168 was "perceived as outstanding", 168 users nevertheless were found to have "little reserve capacity", most 168 processor accounts required "hardware upgrade" and users perceived the 168-3 performance increases as "not significant", and its price/performance as then "insufficient". (DX 9399, pp. 16, 14, 15, 22; see DX 3429.)

<u>Second</u>, 64% of the 100 or so 168 and 158 processor users examined were "actively considering alternatives to doing their work other than with large processors", such as through multiple small processors or by off-loading function to smaller processors. (Akers, Tr. 96886-87; DX 9399, pp. 12-13.) If IBM was going to keep that business, it had to either improve the price/performance of the central site or offer equipment that could perform the "offload" functions in a cost-effective way.

<u>Third</u>, 40% of the accounts were already considering a "plug-compatible processor alternative". There was Amdahl "sales activity in virtually all of [the] 119" accounts surveyed. (Akers, Tr. 96905; DX 9399, p. 13.)

In February 1976, IBM announced the 3062 "attached processor" for the 370 Model 168--"Lexington". (DX 9405, p. 287.) This new processor, based on IBM's announcement letter, would provide a

168 processor with 1.5 to 1.8 times the power of a single 168-3 processor, for only a 50% increase in price. (Id., pp. 287, 291, 293.)

Similarly, the new 158 "AP" processor, announced in October 1976, would provide a 158 processor with 1.5 to 1.8 times the power of a single 158-3 processor, for less than a 25% increase in price. (Id., pp. 459, 464, 469.)

f. IBM System/370 138 and 148 Processors. In June 1976, IBM again introduced new, improved System/370 processors.

Just the preceding November, IBM had announced improved Model 125 and 115 processors: the Models 125-2 and 115-2 (DX 9405, pp. 237, 248), and had also, as just discussed, introduced the 168 "AP" in February. Now, in June 1976, IBM announced:

> The 138 processor, a "growth system" for 370 Model 125 and 135 users, which offered up to 36% increased internal processing speed over the 135. (PX 4541, p. 1.)
>
> The 148 processor, which offered up to 43% increased internal processing speed over the 370 Model 145. (PX 4542, p. 1.)

The 138 and 148 processors used IBM's most advanced circuitry, including Riesling and SNIPE memory circuits, which offered the advantage of greater circuit density than other technologies and lower price. (E. Bloch, Tr. 91542-44.)

In June 1976, IBM also introduced "accelerated processors" for the 135 and 145--the Models 135-3 and 145-3. (DX 9405, p. 395.)

These new models constituted field upgrades that allowed existing 135 and 145 users to achieve performance "similar" to the new 138 and 148 models, without changing processors. (Id.)

The price/performance improvements reflected in the 138 and 148 announcements represented a significant competitive thrust by IBM, to make its System/370 line more attractive to users. In addition, as we noted previously, in June 1976, IBM also began to offer approximately a 9% price reduction for customers who took any of its virtual memory System/370 processors under the optional Term Lease Plan. (See pp. 1053-54 above.)

g. IBM Series/1 Computer System. In November 1976, IBM announced the Series/1 computer system. (DX 13380.)

The Series/1, at announcement, consisted of a variety of processing, storage and input/output equipment, including:

(i) two processors which could support up to 128,000 bytes of memory (id.);

(ii) monolithic semiconductor main memory (E. Bloch, Tr. 91551);

(iii) fixed disks with 9.3 megabyte capacities, as well as "diskette" disk subsystems, each with one-half megabyte of storage capacity. (DX 13380, p. 2.)

At announcement, the Series/1 equipment was offered with little applications or systems control programming and on a purchase only basis. (Id., p. 3.) In these respects, the marketing methods used with IBM's Series/1, as announced, were similar to those of so-called "mini" and small computer manufacturers of the 1960s. (See pp. 716-17 above.)

The announcement literature said that the Series/1 was principally for "the self-sufficient customer who has the capability to do much of his own application programming and may desire to perform systems integration and develop a tailored control program. Such customers are primarily interested in multiple systems deployed to locations performing essentially the same application." (DX 13380, p. 3.) And in 1978 an IBM manual further explained the Series/1 by stating that it was offered as "an alternative" within IBM's own product line "to the fully supported, application-oriented, product that IBM has traditionally offered. It is a 'tools-oriented' offering which allows the user to customize his system to fit his application needs". (DX 9402, p. 26.)

IBM quickly announced improvements and enhancements to the Series/1 equipment and software. In April 1977, for example, IBM announced new operating system software, called the Realtime Programming System (RPS). According to IBM, RPS:

> "provides an operating system through which a user can install, operate, and maintain system programs, application programs, and data. The Realtime Programming System manages all physical resources--processor storage (up to 64K bytes), and I/O devices. Its supervisor and data management services provide a high-level, controlled interface between application programs and the Series/1 hardware. Realtime Programming System, in conjunction with [earlier announced systems software], supports both realtime and batch program environments." (DX 14431, p. 1.)

By March 1979, the Series/1 "menu" of equipment included:

(i) eleven processors;

(ii) up to one billion bytes of on-line disk storage;

(iii) six tape drive models;

(iv) an IBM System/370 channel attachment device;

(v) communications control programming which permitted Series/1 equipment to operate on-line as part of larger IBM systems;

(vi) higher-level language compilers, including COBOL, PL/1 and FORTRAN;

(vii) three systems-control-programming systems; and

(viii) a series of separately priced "programming packages" for such applications as "energy management, data management, networking, intelligent data entry, interactive processing, and remote job entry." (DX 9401, pp. 4, 19-20.)

As explained to IBM's sales force in 1978, the Series/1, was "a family of powerful, low cost, modular general purpose computers that can be applied to virtually any computing task: distributed data processing, traditional business data processing, scientific computing and sensor-based applications". (DX 9402, p. 26.) By 1979, the Series/1 was being used or marketed for an array of applications, including:

Auto dealer services, security and vehicle testing;
warehouse document preparation;
international banking/foreign exchange operations;
customer order service and invoicing;
bulk terminal order entry/invoice preparation;
plant execution, production monitoring, material handling, process control;
employment security;
telephone directory assistance;
purchase order writing; and
research laboratory automation. (DX 9402, pp. 118, 132-33, 166, 299-300, 306, 317-19, 339-41, 399, 469, 478-80.)

In 1979, a marketing guide for IBM salesmen said this about the Series/1:

"Series/1 is powerful enough to be used in a stand-alone capacity and flexible enough for distributed processing. Series/1 represents IBM's response for a small computer system that can span batch and distributed environments in both business and industrial application areas." (DX 9401, p. 20.)

h. Memory Price Reductions and the 303X Processors. In January 1977, IBM's DP Commercial Analysis department presented a "Review of Competitive Memories" to Paul Rizzo, Group Executive of the Data Processing Product Group, John Akers, IBM Vice President and Assistant Group Executive, Plans and Controls, Data Processing Product Group, and Dr. Jack Bertram, President of The System Products Division. (Akers, Tr. 96506, 96997-98.) The presentation reviewed competitive memory prices from "systems vendors", including Amdahl, Burroughs, CDC, Data General, DEC, Hewlett-Packard, Honeywell, NCR, Texas Instruments, Univac, Fujitsu and Hitachi, and from independent memory competitors such as Ampex, AMS, Cambridge, EM&M, Fabri-Tek, Intel and National Semiconductor. (DX 9411, pp. 4-5, 10.)*

The presentation suggested that independent memory competitors and "minisystem" memories had come to the point where they were priced between 40 and 60 percent lower than IBM's, that "traditional systems memory" prices looked "generally higher than IBM", but that PCM activity "could impact" those prices and further that "compatible systems" memory showed "decreasing prices" and "improved memory technology." (Id., p. 17; see Akers, Tr. 96998-97000.)

In March 1977, IBM made two announcements, one a price cut and the second, an announcement of what became the company's

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* Ampex and Fabri-Tek are shown as manufacturing only core memories, for IBM's 155 and 165 processors. (DX 9411, p. 10.)

"most powerful" processor, the 3033. (DX 3748, p. 15.)

First, the price cut.

In March, IBM announced roughly a 35 percent price cut on the purchase, rental and lease prices for memory on all of these 370 processors: 168, 158, 148, 138, 125 and 115 and 3704 and 3705-II communications controllers. (DX 9405, p. 558; DX 14224.)

Second, in March, IBM announced its 3033 processor. (DX 9405, p. 553.)

The 3033 was a "compatible member of the System/370 family of computers" (DX 3748, p. 15) and was, like all other 370 processors, capable of using existing IBM peripheral equipment and programming. The price/performance improvement represented by this processor was impressive. According to IBM's announcement literature to its sales force, the 3033 processor with four megabytes of memory offered nearly twice the processing power of a four-megabyte 168-3 processor, IBM's previous largest model, at only a 12 percent increase in purchase price. (DX 9405, pp. 556, 562.) And, according to IBM, a 3033 with eight megabytes of memory offered nearly twice the processing power of an eight-megabyte 168-3 processor, at only a 13% increase in purchase price. (Id.)*

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* Hart of General Motors, made this price/performance comparison about the IBM 3033 processor:

> ". . . if I compare the 360 Model 65 with the recently announced IBM 3033, which we plan to install at the end of this year, and based upon the public's information about that and some

Moreover, used with the 3033 processor as well as the 158-3 and 168-3 processors, was System/370 Extended Facility, which was supported by a new enhancement to IBM's operating system software, the MVS/System Extensions program product. The MVS/System Extensions software was announced as being able to achieve, in addition to the other price/performance improvements mentioned:

> "A combined projected throughput improvement of about 14% and an expected reduction of control program supervisor state execution time of 20% for certain uniprocessor environments. Multiprocessing improvements provide even greater throughput potential for AP and MP installations." (DX 14430, p. 1.)*

In October 1977, IBM introduced the 3031 and 3032 processors--both were 370-compatible and both offered major price/performance gains for users. (DX 9405, p. 653.) The 3031 processor, according to IBM's announcement, offered up to 2 to 2.5 times the internal processing speed of an IBM 148 processor at less than a 4% increase in purchase price. (Id., p. 561, 658.) The 3032 processor offered internal processing speed of up to 2.5 to 3 times greater

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> benchmark tests which we have run, it is our estimate that the speed of the 3033 compared with the 360/65 is increased by a factor of about 7. The memory size available has increased by a factor of about 10. And the cost per problem solution has gone down by a factor of about 5.'
>
> "So that the costs of a problem which was $10 on a 360/65 would be about $2 on a 3033." (Tr. 80398.)

* The MVS/System Extensions software option was offered by IBM at a separate price. (DX 14430, p. 4.)

than the 158-3 processor for only a 2% increase in purchase price. (Id., pp. 561, 677.)

According to Welch of the Chemical Bank, the 3032 cost about the same as a 370/158, but offered the performance capability of a 370/168 Model 3. (Tr. 74855-56.)

In the months following the 3031/3032 processor announcements, IBM made additional 303X processor product announcements. In March 1978, IBM introduced the 3033 multiprocessor complex (MP), offering, according to its announcement material, "a higher level of performance, greater operational flexibility and enhanced availability features compared to a 3033 uniprocessor". (DX 9405, p. 743.) IBM stated that the 3033 multiprocessor complex was capable of performance rates 1.6 to 1.8 times greater than a 3033. The multiprocessor could accommodate a maximum of 16 megabytes of main memory and 32 channels. (Id.)

In September 1978, IBM introduced the 3031 Attached Processor (AP) complex, up to 1.6 to 1.8 times faster than a single 3031 for at most a 45% increase in price. (DX 9405, pp. 658, 816, 820, 821.)

i. <u>IBM Announcements: October 1978-January 1979.</u> In the months from October 1978 through January 1979, IBM announced a number of major new products and price cuts, including these:

<u>First</u>, in October IBM announced two new computer systems, the System/38 and 8100. Both were based on IBM's new "64K" semiconductor chip, manufactured through IBM's newly-developed FET process, "SAMOS" (Silicon and Aluminum Metal Oxide Semiconductor). This chip was the most dense chip ever announced. The density was achieved by fabricating single device memory cells which were so tiny that 200 of them could be covered by an amoeba. (E. Bloch, Tr. 91545, 93349-50; DX 8903, pp. 3-4.)

<u>The System/38</u> is "certainly in the intermediate systems range". (Akers, Tr. 96687; see also Tr. 97923-24, 98056-57; DX 13383, p. 1.) At announcement the System/38 offered nearly 50 times the memory available on the System/3, and 50 percent more memory than the System/370 Model 138. (PX 4541, p. 4; DX 8073, p. 2; DX 13378, p. 1; DX 13383, p. 2.) In December 1979, the System/38's maximum memory capacity was increased from 1.5 million bytes to two million bytes--the same capacity available on the System/370 Model 148. (PX 4542, p. 4; DX 14429, p. 1.)

Withington called the System/38 "the most innovative of the new small IBM systems". (DX 12690, p. 12.) His report continued:

"System/38, like the other new IBM small systems, utilizes state-of-the-art semiconductor technology with memory using 64,000-bit chips and the processor using LSI circuitry with up to 704 circuits per chip. IBM claims that these processing circuits have more than 25 times the capacity of the processor logic chips employed in the IBM System/3.

"The most interesting and potentially most important parts of the System/38 announcement are not in the hardware but in the software. All parts of the system including the control program facility, the RPG language processor, and the interactive data base utilities were designed as an integrated whole to provide a very smooth and easy-to-use user interface. The data base management software is completely integrated into the control program facility and is basic to the system operation, as contrasted with older systems where a data base system was a complex option." (Id.)

The System/38 was, as Withington noted, announced with new operating system software, called Control Program Facility (CPF), which offered, among other capabilities, data base management and communications--including the ability to use the System/38 "as a terminal . . . to System/370". (DX 14428, p. 1.) Of the System/38's data base capabilities, an IBM manual explained:

"System/38 is the first computer system to have a full function data base facility designed as a part of the basic machine. The data base capability is . . . comparable to data base systems previously available only as applications on more expensive machines. All online data in System/38 is stored, manipulated, and accessed through the data base component. The extensive capabilities of the data base facility are designed to be available to the user at whatever level of function and sophistication is needed. The S/38 data base facility was an intrinsic part of the over all design of the system." (DX 9401, p. 37.)

The same manual further states:

IBM's System/38 is a new general-purpose data processing system designed for the interactive workstation environment. For the implementor of Distributed Data Processing (DDP), S/38 provides unique data base, ease-of-use, and price/performance characteristics. S/38 puts the computer where the users are by making both data base and processing power accessible to end users and programmers." (DX 9401, p. 22.)

A significant aspect of the System/38, from a user's perspective, appears to lie precisely in the system's combination of "ease-of-use" and its "intermediate" processing and storage capabilities and the advanced control functions, discussed above. The ease-of-use design facilitates the products' use with "both experienced and first-time computer users" (DX 14447, p. 11), while the performance capability permits the system to tackle larger tasks in a stand-alone environment.

<u>The 8100.</u> At its announcement in October, IBM stated that the 8100 product line "responds to the growing customer requirement for distributed data processing (DDP) solutions. . . ." (DX 9405, p. 840.)

The 8100 system included at announcement:

(i) two processors (8130 and 8140) which could support up to 512K bytes of main storage, more storage than was available on the System/360 Models 30, 40 or 50, announced in April 1964 (JX 38, p. 32; DX 9405, p. 840);

(ii) removable diskette storage of up to 1 megabyte (DX 9405, p. 840);

(iii) new CRT input/output equipment as well as software and hardware to permit attachment of existing IBM I/O equipment (id., pp. 840, 843; DX 9405, p. 1);

(iv) data base management software and system control programming to allow "the integration of networks of 8100s and System/370s. The remote user can utilize the function of the 8100 System and can also call on much of the power of a host System/370." (DX 9405, p. 844.) New system control or operating system software was announced with the 8100, called DPCX and DPPX. (DX 14427, p. 1; DX 14308, p. 1.)

Of the 8100, Withington wrote:

> "The 8100 is intended mainly for large users interested in distributed procesing [sic] networks. It offers more autonomy of operation than IBM has hitherto made available in its network controllers, and is very cost-effective; the 8100's speed and cost equal the best of the competitive systems. It has attractive new software and terminal control capability, and supports the increasingly popular System Network Architecture of IBM. It can also operate as a stand-alone computer system, but given the virtues of the other recently announced IBM small computers [the System/38] . . . the 8100 is likely to be used mostly in its intended network processing role." (DX 12690, pp. 11-12, footnote omitted.)

Second, also in October, IBM cut rental, lease and purchase prices on its 3350 and 3344 disk systems. (DX 9405, p. 940-42.)

Third, in November, IBM announced enhancements to the

3850 Mass Storage System (see pp. 1060-63 above) consisting of featu[res] that permitted the system to use the advanced 3350 disk drives as "data staging devices" rather than 3330 Model 11s. (DX 9405, pp. 959-60.)

Fourth, in December, IBM announced additional memory increments for the 3033 processors, raising the maximum memory available on that processor to 16 megabytes, twice the maximum memory on the IBM 370 Model 168 and approximately 2-1/2 times that of the 158. (DX 9405, pp. 293, 473, 971.)

Fifth, also in December, IBM again announced rental and lease price cuts of up to 20 percent and purchase price reductions of roughly 30 percent for FET memory increments on System/370 processor Models 115, 115-2, 125, 125-2, 138, 148, 158, 158-3, 168, 168-3, the 3031, 3032 and 3033 processors, and the 3704 and 3705-II communications controllers. (DX 9405, pp. 974-88; DX 14426.)

Sixth, in January 1979, IBM announced the "attached processor" for the 3033 processor, called the 3042. According to the IBM announcement:

> "The 3042 Attachment Processor improves the 3033 instruction execution rate generally in the range of 60 percent to 80 percent for only 37 percent additional cost." (DX 9405, p. 1006.)

Seventh, also in January 1979, IBM announced two more new System/370-compatible processors, the 4331 and 4341. (DX 9405, pp. 1013-33.) According to IBM's announcement literature, "The IBM 4300 Processors combine System/370 compatible architecture and advanced technology with new I/O units and attachment facilities to provide greatly improved price/performance and function. . . . [T]he new IBM 4331 and 4341 Processors offer a broad range of support for both distributed and standalone applications." (Id., p. 1013.)

Both the new processors were built on IBM's advanced "64K" chip technology. (E. Bloch, Tr. 91547; DX 9405, p. 1013.)

The price/performance improvements represented by these processors were recognized as dramatic, even in the context of IBM's price/performance jumps of the preceding two years or so. For example, Withington stated:

"The most outstanding feature of the 4300's is their price performance. The model 4331 with 500,000 million [sic] bytes of storage sells for $65,000 without peripheral equipment; IBM says it is four times as powerful as the original System 370 model 115 (the smallest 370), which had a substantially higher price and a much smaller memory. Similarly, the larger 4341 is stated to be three times as powerful as the medium-priced System/370 model 138 and will sell at a price comparable to it ($245,000 without peripheral equipment), but has a much larger memory (2 million bytes). The price/performance of these two new systems equals or betters that of any comparable products in the industry." (DX 12690, p. 13.)

John Akers of IBM made this comparison: the 4341 has approximately the same internal performance as the 370/158 for about the price of a 370/138 (less than one-quarter the price of the 158), and nearly the same internal performance as the 3031 for about half the price. (Akers, Tr. 96691-94; DX 9405, pp. 979, 1044, 1049.)

The 4300 computers also represented significant price/

performance improvements in terms of memory. The memory on each 4300 processor had a purchase price of only $15,000 per megabyte, less than one-fifteenth the cost of memory on the 158 and 168, approximately half the cost of memory on the System/38, and over 15 percent less than the cost of the memory on the 8100 (E. Bloch, Tr. 91547)--the latter two announced just several months earlier.

In addition to these measures of improved price/performance, the 4300 series processors were said to offer reductions in power consumption, cooling and space requirements, and improved reliability and serviceability. (DX 9405, pp. 1030, 1044.)

The overall price/performance attractiveness of the 4300 processors translated into benefits to computer customers for many different functions thus greatly increasing the flexibility of IBM's computer product line:

The processors would obviously be attractive as replacements for existing IBM System/370 processors and were offered as such. (DX 9405, p. 1013; see also DX 12690, pp. 13-14.)

Although the 4300 processors have the performance of IBM's "earlier" middle to large 370 processors, their low cost would make them attractive to first-time computer users. And the processors were so offered. For example, in the 4331 announcement letter, IBM's sales force was told:

> "The price/performance and range of capabilities of the IBM 4331 can enable online computing and distributed applications to be cost justified by many new users." (DX 9405, p. 1029.)

The 4300 processors, with their lower costs and reductions in power consumption, cooling and space requirements, were immediately attractive for use in distributed data processing configurations, as well as in the traditional "standalone" system environment. Hence:

(i) at announcement, IBM marketed the new processors for "Distributed applications", "Distributed data applications" and "Distributed network[s]", with communications links with "one or more host processors", with "peer" processors, or with other IBM processors. (DX 9405, p. 1015.)

(ii) in March 1979, IBM included the 4331 and 4341 processors, which were said to "offer a range of distributed and standalone data processing solutions" in its "Small Systems Product Differentiation Guide". (DX 9401, pp. 23-24.) Both processors were described as being "especially attractive" for numerous distributed data processing uses. (See DX 9405, p. 1044.)

In reviewing the 4300 Series processors prior to approval for announcement, IBM's top management (Corporate Management Committee) reviewed the prices of some of the competitors' products, including those of: NCR, Univac, DEC, Burroughs, Honeywell, Hewlett-Packard, Data General, NCSS, Magnuson, National Semiconductor, CDC, Itel, Amdahl, Two-Pi, CMI, Citel and Nanodata. (Akers, Tr. 96940-52; DX 9395, pp. 9-10, 14-15, 17, 25.) According to Akers of IBM, they were chosen as "current examples of the competition" and "representative competition". They were taken into account because "those products were competing for business that the 4331 and 4341 processors were being announced to compete for". (Akers, Tr. 96947-50; see also Akers, Tr. 96956-59.)* Akers also testified that the 4331 and 4341 have met competition from "traditional competitors" such as NCR, Burroughs, Honeywell, Univac and DEC, as well as from manufacturers of plug-compatible processors, leasing companies, and suppliers of small systems, such as Data General, Hewlett-Packard and Wang. (Tr. 96956-57; see also DX 9407, which lists the following companies as having been "active against the 4331" during April and May 1979: Burroughs, Data General, DEC, Hewlett-Packard, Honeywell, NCR, Prime and Tandem.) Akers added that Japanese computer manufacturers, such as Hitachi and Nippon Electric Company, also compete with IBM's 4300 processors. (Tr. 97031.)

As part of the 4300 announcement, IBM announced several new peripheral products (DX 9405, pp. 1051-59, 1068), including the IBM 3370 disk drive. (Id., pp. 1055-58.)

The 3370 drive presented "major improvements" in technical

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* Withington testified that in pricing the 4331 and 4341, IBM should have taken into account the products of a variety of competitors, including large systems vendors, plug compatible CPU vendors, plug compatible peripherals vendors, small business systems vendors, and foreign manufacturers, including "those not now offering machines in the United States. All of those would be actual or potential forces serving to make up my mind as to what I felt the price level should be for these new products." (Tr. 112935-44.) The companies Withington identified by name were: Burroughs, Honeywell, Sperry Univac, DEC, Amdahl, Itel, Magnuson, Two Pi, Wang, Hewlett-Packard, Data General, Prime, Fujitsu, Hitachi and Siemens. (Id.)

performance and in price over IBM's 3350 drive, announced in 1975. (See p. 1297 above.) For example:

(i) The 3370 offered 571.3 megabytes of storage per disk spindle, compared with a maximum storage capacity on the 3350 of 317.5 megabytes per spindle. (PX 4540, p. 1; DX 9405, p. 1055.)

(ii) "Recording density [is] more than twice that of the IBM 3350." (DX 9405, p. 1055.)

(iii) The announced average access time of the 3370 was 20% faster than that of the 3350, and the rate at which data could be transferred from the disk device to a CPU was more than 50% higher on the newer drive. (PX 4540, p. 1; DX 9405, p. 1055.)

The 3370 achieved these performance advances in part through "[n]ew read/write heads and high density LSI circuitry combine[d] with fixed media". The 3370's read/write head was an advanced "thin film". (DX 9405, p. 1055.)

IBM's use of thin film technology dates back to work done in the 1960s on thin film main memory for certain System/360 processors. (See pp. 282-87 above.) In the course of that work, IBM researchers developed an advanced electroplating technique which was adaptable to the construction of disk heads, and IBM was thus able to make a smaller, cheaper head, in turn facilitating the recording and reading of smaller magnetic bits of data, packed more closely together on the disk surface. (Gomory, Tr.

98273-80.)

At announcement, the 3370 was offered for attachment to the IBM 4341 processor, via a new 3880 control unit and to the IBM 4331 processor, via a "DASD Adapter" physically integrated within the 4331 CPU. (DX 9405, pp. 1055, 1059.)*

In June 1980, IBM announced two more new disk drives, the 3380 and 3375, with fixed head and disk assembly and still greater capacities. (DX 14297; DX 14296.) The 3380, the higher capacity drive of the two, is said to provide 1.25 billion bytes per disk spindle--over a 12-fold increase compared with the 3330 announced 10 years earlier. (DX 1437, p. 3; DX 14297.) In addition, the 3380's data rate exceeded by 60 percent that of the 3370, announced only a year and a half earlier.**

While these capacity increases have been achieved, prices for storage have been driven down: in the case of the 3330, one dollar of monthly rental bought about 145 thousand bytes of disk storage; for the 3350, announced in 1975, a dollar bought 470 thousand bytes; for the 3370, announced in 1979, a user obtained 810.3 thousand bytes of storage per rental dollar; and for the 3380,

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* The 3880-1 controller also attached the 3340 and 3344 disk drives to the 4341 processor. (DX 9405, p. 1059.) The 3880-1 offered an increased capability to handle the flow of data and, according to IBM, was designed to improve the availability and reliability of the data stored on attached disk drives. (Id., pp. 1059, 1061.)

** The 3380 is offered for attachment to IBM's 303X series, and to the System/370 Models 158 and 168, via the 3380 control unit. (DX 14297.)

announced this year, the capacity per dollar is 1,191.5 thousand bytes. (DX 1437, pp. 1,3; DX 9405, pp. 174, 178, 1055, 1058; DX 14297.) All of this, of course, is not adjusted for inflation.

As with IBM's System/360 and System/370 announcements in earlier years (see pp. 376-83, 981-1000 above), competitive suppliers responded to IBM's late 1978 and early 1979 announcements even before the products could be shipped. The trade press chronicled the competitive pricing and product announcements in the months following these 1978-1979 announcements. The record of these competitive announcements demonstrates the aggressiveness of computer suppliers and illustrates the variety of their alternative offerings.

(i) November 1978

NCR announced two new computers, reportedly, "to counterattack IBM's recently unveiled System/38." The two new systems, called the I-8270 and I-8410, extended the 8200 line, utilizing 16K-bit chips instead of the 4K-bit chips used in the earlier models, and offered in the larger model up to one megabyte of memory and up to 648 megabytes of disk storage. It was reported that the two models offered "greater capacity . . . at sharply lower prices" than NCR's earlier machines. (DX 14266.)

STC announced what it claimed to be a major breakthrough in disk drive technology: the doubling of the track density on its IBM-compatible, 3350-type disk drive. The new product, the Model 8350, was claimed to offer a 20 to 30 percent price advantage over comparable capacity from IBM. (DX 14281.) CDC had announced two months earlier an IBM 3350-compatible disk drive, called the Model 33502, with double the capacity of the IBM 3350, giving it a capacity of 635 megabytes per spindle and 1,270 megabytes per cabinet. (DX 14240.)

(ii) December 1978

Nippon Electric Company or NEC announced the NEAC MS10 at the low end of its MS computer line, reportedly designed to compete directly with the Series/1, and the N4700 system, reportedly designed to compete with IBM's 8100 and other systems. The MS10 was announced with a maximum memory of 64K words and intended for distributed processing, communications and industrial process control applications. The N4700 system was announced with two models, the larger with a memory of 1 megabyte. (DX 14267.)

(iii) January 1979

Prime introduced four new computers, the Prime 450, 550, 650 and 750. (DX 12373, p. 5.) The 750, the largest, could support 8 megabytes of main memory, a variety of programming tools, such as COBOL, FORTRAN and PL/1, and Prime's data base management system. (DX 11907; DX 14230.) Prime advertised: "if what you really need is 4300 capability, you can have it in 90 days. From Prime Computer". The ad invited users to "Compare performance. Our Prime 750 and

550 have outperformed IBM's 4341 and 4331 in computational benchmarks." (DX 14272.)

Burroughs announced a dual-processor version of its B1800 computers and two "repackaged" models, reportedly priced to respond to the IBM System/38 and effectively replacing the existing B1800 line. The dual-processor version was claimed to offer 50 percent better performance than Burroughs' previous largest model in the line. (DX 14232.)

(iv) February 1979

Nippon Electric Company announced the Acos System 250, which NEC reportedly claimed had better price/performance than the IBM 4331. (DX 14415.) NEC also stated that the Acos 250, in addition to on-line processing, was capable of doing interactive processing and could be used as a host or distributed processor in a network system. (Id.)

Burroughs introduced the "B900 Series" with the announcement of the B2930 and B3950 computer systems. (DX 14235.) The two processors were compatible with Burroughs' earlier "B800 Series" systems, and could be linked to form loosely-coupled multiprocessor complexes with up to four CPUs. (DX 14235; DX 14407.) A Burroughs spokesman was reported as saying that the B2930 offered greater throughput than the 4331 at a slightly higher price while the B3950 offered equivalent performance to the 4341 at a slightly lower price. (DX 14235.)

Itel announced a new IBM plug-compatible processor, the

AS/3 Model 5, which it claimed provided up to 22% better internal performance than the 4341. (DX 14449.) The AS/3 Model 5, an extension of Itel's Advanced System (AS) Series of IBM-compatible processors, was manufactured by National Semiconductor. (DX 14408.) The AS/3 Model 5 could support a maximum of 8 million bytes of memory, compared to the 4341's maximum capacity of 4 million bytes. (DX 14408.)

NCR introduced four new processor models in the Criterion, line, the V-8555M, V-8565M, V-8575M and V-8585M. (DX 13859-A.) The four systems could be run in either uniprocessor or multiprocessor configurations. The top two systems were said to offer performance equal to the 4341, while the lower two bracketed the 4331 in performance. (Id.)

Siemens announced a new model of its 7.000 series, called the 7.706, with a minimum configuration of 384K bytes of main memory and two 60 megabyte disk drives, reportedly as its "answer" to IBM's System/38 and 4331. (DX 14277.)

(v) March 1979

CDC announced a new IBM plug-compatible processor in its Omega line, developed by IPL and reported to range in cost from $360,000 for a CPU with two million bytes of memory to $560,000 for an eight million byte system. (DX 14104.) CDC reportedly claimed that "the Model 3 is 1.3 times faster than the published specifications for the

IBM 4341." (Id.)

Kardios Systems announced a new version of Perkin-Elmer Corporation's "3220 Supermini", which Kardios was acquiring on an OEM basis from Perkin-Elmer. Kardios described the new processor, the Duo 70-E, as offering full IBM 370 compatibility and as matching the throughput of the 4341. (DX 13935.) Kardios reportedly created the system through changes to the 3220's firmware, which permitted the processors to run IBM programming code and to accept IBM peripherals under Perkin-Elmer's operating system. (Id.) A Kardios spokesman claimed that the Duo 70-E delivered three times the throughput of IBM's 4331 system. (Id.)

Magnuson introduced three new IBM plug-compatible processors, the M80/32, M80/42 and M80/43; upgraded its earlier M80 models 3 and 4; and reduced the prices of those earlier models. (DX 14403.) Magnuson claimed the new processors bracketed the 4341 in performance and had faster machine cycle times than the 4341 and that the top of the line, the M80/43, offered 30% better performance than the IBM 4341 and a maximum memory capacity of 16 million bytes, four times the maximum capacity of the 4341. (DX 14403.)

Data General reduced prices for its Eclipse computers by more than 50 percent and also announced expanded memory capacity for most of the Eclipse systems. (DX 14444.) Data General reduced memory prices on those systems to $28,000 per megabyte. (DX 14349.)

Mitsubishi announced a pair of new processors: the "700S", which, the firm stated, offered four times the power of IBM's 4331; and the 700 III, which it claimed was twice as powerful as the 4341. (DX 14416.) Mitsubishi also claimed that the computers featured interactive and distributed processing capabilities. (Id.)

Honeywell introduced four new processors: the Level 64 Distributed Processing System DPS-320, which it claimed had equal price/performance to the 4331; the Level 64 DPS-350, which it stated had about 70 percent greater performance than the 4331; the Level 66 DPS-440, which was "somewhat" under the IBM 4341 in both price and performance; and the DPS-520, which was said to provide about 1.5 times the performance of the DPS-440. (DX 13603.) The four new systems were designed to work within the Honeywell Distributed Systems Environment as host or co-host processors and they offered software compatibility with the firm's Level 6 "minicomputers". The memory for the Honeywell processors was priced at $23,680 per megabyte, compared to IBM's price of $15,000. (Id.)

(vi) April 1979

CDC introduced four computers, the CYBER 170 Series 700, which replaced five of the six models in its earlier CYBER 170 line, and which were said to offer significant price/performance improvements. (DX 14105; DX 14106.) In addition, Control Data reduced prices of incremental memory on its processors by from 20 to 53 percent. (DX 14105; DX 14106.)

DEC reduced prices by up to 30 percent on the memory for its DECSystem 20 line. (DX 14417.) The price reductions were viewed by the trade press as a response to the performance/price improvements of the 4300 Series. (DX 14417.) DEC also increased the maximum memory capacity to 6 megabytes for the 2060 and 2040 processors, compared with a maximum of 4 megabytes for the 4341. (Id.)

Fujitsu introduced four new processors in its M Series 370-type computers, the FACOM M-130F, M-140F, M-150F and M-160F. (DX 14418.) Fujitsu rated the 130F about equal in performance to the 4331 but 20 percent cheaper, and the 140F equal in price to the 4331 but 60 percent more powerful. The Model 150F was graded slightly below the performance of the IBM 4341 but featured a 25 percent price advantage and the 160F was approximately the same price as, but 10 percent more powerful than, the 4341. (DX 14418.)

Siemens announced the Model 7.521, 7.531 and 7.541 processors, reportedly, "in an effort to fight off the challenge from IBM's 4300 series." The report stated that the Siemens "hardware is offered at rock-bottom prices." (DX 14278.)

(vii) May and June 1979

Two-Pi introduced an IBM plug-compatible processor, the 3200-V, said to offer approximately twice the performance of the 4331. (DX 9410, p. 10)

Univac announced the 1100/60 system. This multiprocessor-based system was offered in four single processor and two multiprocessor configurations and was said to range from slightly below the performance of the 4341 to about the performance levels of the IBM 3032. (DX 13792.)

Wang introduced the VS/100, which it claimed provided eight times the performance of the prior Wang virtual storage computers and supported up to 2 megabytes of main memory and 4.6 billion bytes of on-line storage. (DX 14450.) The trade press stated that the Wang VS/100 was directed primarily at the IBM 4300 Series but that the company claimed capabilities extending into the IBM 3032 range. (Id.) Throughout 1979 and 1980, Wang aggressively marketed its systems to prospective IBM 370 and 4300 users. (See DX 12078; DX 12076; DX 12075; DX 12077; DX 12074; DX 12073.)

DEC cut its memory prices by as much as 60% for its VAX-11/780, PDP-11/70 and PDP-11/34A, and announced additional price reductions for its DECSystem 20 line. Industry observers attributed the DEC price cuts to "the pressures established by IBM in the past six months with its 8100 and 4300 processors, which use 64K bit chip technology, priced at $15,000 per megabyte". (DX 13927.)

(viii) July-September 1979

Hewlett-Packard reduced the prices of its largest systems in July, by 12 to 18 percent, in part by reducing the price of memory to $15,000 per megabyte. (DX 14254.) In September, Hewlett-Packard announced a new, low-price version of its 3000 series called the HP 3000 Series 30 and a new intelligent network processor (INP) which was to use "silicon-on-sapphire microprocessors and 32K bytes of on-board RAM to take over communications management tasks from the CPU". (DX 14253.)

Nixdorf introduced a new series of systems offering higher performance and lower prices than its previous line and reportedly "aimed directly at IBM's 8100 systems". It was claimed that the new series bracketed the 8100 in terms of price/performance. (DX 14268.)

(ix) October 1979

Paradyne announced the Response system, a network system consisting of an IBM 370 "oriented" processor with up to 2 million bytes of main memory, a transaction-oriented operating system and peripheral equipment. (DX 13896, p. 12; DX 13934.) According to an industry source, Response is "[a] distributed data processing . . . network system aimed at IBM users that reportedly eliminates the need for IBM teleprocessing software." (DX 13934.) The "Response" system was reportedly "aimed" at IBM's 4331 and 8100. (DX 14269.)

In addition to these announcements, leasing companies, with both 360 and 370 computer equipment, offered that equipment in competition with IBM's 4331 and 4341 processors. (Akers, Tr. 96956-57).

Some examples of the competition facing the 4300 Series are presented in an IBM Data Processing Division "Competitive News Release" of October 1979. (DX 9408.) Although this report does not purport to be a complete listing of all wins and losses involving the 4300 processors, it does present some indication of the competitive activity. According to the report:

(i) There were 306 bids involving new opportunities or replacement of IBM installed equipment.

(ii) The leading competitors in the 4331 bid situations included Honeywell (including the Honeywell Level 6 systems), DEC, Hewlett-Packard, Univac, Burroughs, Wang, and Itel.

(iii) Of the fifty-three reported 4331 situations that had been resolved, IBM won 27.

(iv) In the 4341 bid situations, the leading competitors included Itel, CDC, DEC, Burroughs, Univac and Honeywell.

(v) Of the forty-nine reported 4341 bid situations that had been resolved, IBM won 19.

(vi) In the case of both the 4331 and 4341, in addition to the competitors named above, there was substantial competitive activity from third-party leasing companies offering older IBM-manufactured equipment in competition with IBM's new 4300 Series.

IX. CUSTOMER ALTERNATIVES IN THE 1970s: SOME EXAMPLES

76. Introduction. The array of computer products and services introduced by IBM and other competitors in the computer industry during the 1970s offered users a growing menu of choices for performing their data processing tasks. John L. Jones, Vice President of Management Information Systems at the Southern Railway, testified that

> "the entire available set of alternatives that one can choose, first of all, to design how a system is going to be constructed, what the basic concept is behind it, and then once that is determined, how it is to be implemented on specific pieces of computer equipment is just a totally new ballgame as compared to ten years ago." (Tr. 78998.)

What follows is a discussion of some of the detailed examples in the record which illustrate the options and equipment, software and service alternatives as seen by a variety of computer customers in the mid-to-late 1970s.* In addition to this detailed testimony, other examples appearing in the record have been included.

What emerges from these materials is the same picture--but now from the buyers' side--of the improved products and increasing alternatives that we have already seen from the suppliers' viewpoint. How customers have chosen to shape their computer systems--what equipment, what programming, what services they may select--is quite varied and becoming more so. That is true for at least these

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* By stipulation dated April 25, 1978, the plaintiff agreed that about 70 "user witnesses . . . would, if called to testify by IBM, testify substantially the same in substance and effect" as the user witnesses called by IBM to testify live as part of its direct case.

reasons:

<u>First</u>, there are more suppliers and more products and services--in number and variety--in the industry than there were even ten years ago.

<u>Second</u>, users have become increasingly more sophisticated in their data processing capability and, consequently, more discriminating and demanding in their procurement decisions.*

<u>Third</u>, steadily and rapidly improving product performance--including the emergence of powerful, low-cost systems and far more cost-effective equipment of all kinds--has given users more flexibility in configuring their systems. That technological progress has, for example, led to increasing use of distributed data processing configurations as alternatives to the more traditional, centralized system. As John L. Jones of the Southern Railway testified, distributed processing and the use of smaller computers in fashioning new data processing configurations "developed with dramatic speed since the turn of the decade to the extent now that should one choose, as I would think any responsible executive in the data processing field would at least need to evaluate, the alternative of . . . distributed processing . . . the problem is not to find alterna

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* In addition to the materials that follow, see also McCollister, Tr. 11051-54; DX 69, p. 5; DX 460, p. 8; DX 467A, pp. 41-42; pp. 932-33, 945-49, 959-60 above.

tives; the problem is to get the alternatives down to a reasonable number which can be evaluated." (Tr. 79321, see also Tr. 79534.)*

Fourth, the increased availability of products from different manufacturers which are compatible with one another--in terms of either hardware (plug-compatibility), software or communication protocols--has made multi-vendor systems commonplace. The products of many different vendors can be and are routinely used together as a single computer system.

* Jones is certainly not alone in his views. See, e.g., Hindle, Tr. 7414-17, 7500-01; R. Bloch, Tr. 7766-67; Beard, Tr. 10050-51; Hangen, Tr. 10433-35; Currie, Tr. 15482-85; Case, Tr. 73887-89; PX 442, p. 84; DX 2760, p. 14; DX 9402, pp. 11-20; DX 12638; DX 13507, p. 5; DX 5346, R. Davis, p. 2; DX 9071, Crone, pp. 130-31, to the same effect.

77. Chemical Bank.

a. Overview of Chemical's EDP Installation: 1978. At the time of his testimony in late May and early June of 1978, James F. Welch was Senior Vice-President in the Information Services Group of Chemical Bank. He assumed that position in mid-1973; for about three years prior to that time he was Vice-President, Management Information and Data Processing, at American Airlines. (DX 3656.) Among his professional activities, Welch was Chairman of the New York Clearing House Data Processing Committee, former chairman of two data processing committees of the International Air Transport Association, and a member of: the Top Computer Executives (a discussion group of data processing executives from various industries (see Tr. 74683-89*)), the Advisory Board of the Diebold Research Program and the Society for Management Information Systems. (DX 3656.)

Welch testified at some length concerning Chemical Bank's data processing applications, the EDP equipment and services used by Chemical at various times to perform those applications and a number of the bank's computer procurement analyses and decisions.

Chemical Bank is one of the largest commercial banks in the United States. It offers a full range of banking services to

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* Unless we indicate otherwise, all transcript notations in this section refer to the witness's own trial testimony in this case. We will use the same convention in each of the following sections.

its corporate and individual customers--commercial and personal loans, mortgages, savings, checking, credit card management, stock transfer, international funds transfer, etc.--virtually all of which require substantial electronic data processing capability.

Welch testified that it was fair to characterize Chemical's computer system, as of mid-1978, as "primarily centralized" (Tr. 75507); that is, "instead of using a substantial number of smaller processors, we have a small number of large processors". (Tr. 75506-07.) As late as December 1976, Chemical was doing "most" of its data processing on a system consisting of four IBM processors (two System/370 Model 165s, a Model 158 and a Model 145) and associated peripheral equipment. (PX 5664, pp. 1, 7-8.) And in 1977, this system was upgraded to two System/370 Model 168s, in addition to the previously installed Model 158. (Tr. 74833-34, 75328-30.)

Three significant points about Chemical's "centralized" system configuration are:

> First, in late 1976, the bank considered and rejected an option proposed in a major study for using minicomputers as communications front-end processors or as "replacements for large-scale computers", as well as a number of other options for increasing overall capacity. (PX 5664, pp. 1, 9-10.) In the 1977-78 timeframe, however, "minicomputers . . . in fact arrived in the bank". (Tr. 75352.) By mid-1978, they were, as we shall describe below, performing

applications previously done on larger systems, and applications for which the larger systems were considered by the bank to be alternatives; they were, in other instances, performing new data processing applications that had not previously been done at the bank.

Thus, while Chemical's computer system remained in June 1978 "primarily centralized", a number of data processing functions and applications had been off-loaded to "minicomputer"-based systems. (Tr. 75352.) In Welch's view, off-loading "would enhance the capacity of the main data center, and it would either make it unnecessary for us to add more capacity or perhaps--and I can foresee this as a distinct possibility--it would give us the opportunity to reduce the size of some of the existing large CPUs". (Tr. 75464.) As of mid-1978, Welch noted, by off-loading, Chemical "had forestalled the increase" of its large CPU capacity. (Tr. 75464-65.)

Because of the potential benefits of off-loading, in 1977 Chemical established a hardware evaluation group, some members of which were directed to focus on the small system offerings of selected vendors such as Univac, Honeywell, IBM, DEC and Data General, in an effort to take applications from the bank's "main New York State computer system" and move them to "smaller general purpose computers".*

* In addition to such individual evaluation efforts, Welch

(Tr. 75235-37, 75285-89.) As Welch observed, "[T]he data processing industry is recognizing that things which manufacturers chose to call 'mini', are . . . in fact capable of performing substantial amounts of data processing work". (Tr. 75299-300.)

Second, Chemical's system configuration--"primarily centralized" with increased off-loading to smaller systems --was, of course, not the only one available for his application. Welch noted, for example, that Citibank, a major Chemical competitor and an even larger commercial bank, has adopted an approach "diametrically opposite" to Chemical's. (Tr. 75648-50.) Citibank's senior data processing personnel have strongly embraced the view that "there is no job so large that it cannot be broken up and performed on small general purpose computers"--that "any job can be broken up and distributed on small computers". (Id.)

Third, as the 1970s progressed, Chemical's EDP installation moved from virtually an exclusive "IBM shop" to a configuration including hardware, software and services supplied by a variety of manufacturers (such as IBM, Storage Technology

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testified that 50 to 60 people were assigned on an on-going basis the responsibility to "evaluate and reevaluate the electronic data processing equipment and services used by the bank". (Tr. 74718.) That effort costs approximately $1 million per year and the "results expected" from it are a forestalling of additional EDP expenditures or a reduction of existing EDP expenditures "in an amount equal to or greater than that." (Tr. 75310-11.)

Corporation, DEC, CalComp, Cipher, Documation, Data Products, Texas Instruments, Data General, Burroughs, Four Phase, Bunker Ramo, Interdata and Hazeltine), leasing companies (such as Comdisco and General Electric Credit), data service organizations (such as General Electric, Interactive Data Corporation and Computer Time Sharing), software suppliers (such as Management Services of America and Mellon Bank) and systems integrators (such as Collins and Arbat).

In mid-1978, much of Chemical Bank's data processing was performed on its "main New York State general purpose computer system". (See Tr. 75045-47.) That system included EDP equipment installed at a number of different geographic locations.

The EDP equipment in operation at Chemical's data processing center located at 55 Water Street in New York City included:

<u>Two IBM System/370 Model 168 central processing units.</u> One CPU was installed in April 1977 and the other in August 1977 (Tr. 74826); both units were leased from Comdisco, a leasing company, on two-year leases. (Tr. 74832-33.) The 370/168s replaced 370/165s which Chemical previously owned. (Tr. 75330.) The replacement was done to increase overall systems capacity. (PX 5664, pp. 8-10; Tr. 75336-7, 75341.) At the time the 168s replaced the 165s, most other boxes in Chemical's main system remained unchanged. Each of the 168s was initially installed with four million bytes of main

memory; an additional megabyte of IBM-manufactured memory was leased from Comdisco and added to one of the processors after consideration of CDC (whose memory would also have been acquired through Comdisco) as an alternate vendor. (Tr. 74847-51.) At the time he testified, Welch was evaluating an additional megabyte for the second processor, and was considering STC (offering National Semiconductor-manufactured memory) and CDC (offering AMS-manufactured memory) as possible vendors. (Tr. 74848-50.)

An IBM System/370 Model 158 central processing unit. Chemical leased this unit in 1975 from General Electric Credit on a four-year lease. (Tr. 74854-55.) The 158 replaced an IBM 370/145. (Tr. 74854.) At the time of his testimony, Welch had placed an order for an IBM 3032 processor which, he testified, would cost about the same as a 370/158 but have the performance capability of a 370/168 Model 3. (Tr. 74855-56.) The 3032 would either replace the 158 or be added to the main system in addition to the 168s and 158. (Tr. 74854-56.)

Thirty-two IBM 3350 disk drives. Those devices, announced in 1975 (DX 9405, p. 174), were being leased from IBM on a two-year lease. (Tr. 74865.)

The 3350s were installed beginning in late 1977 or early 1978 (Tr. 74863); some replaced 3330 Model 11 disk drives, and others were additions. (Tr. 74864.) As of mid-1978, Chemical planned to install at least 16 STC-manufactured 3350-compatible products, STC 8350s, to increase its system's storage capacity. (Tr. 75248-49.) The STC 8350s would replace IBM 3330-11s. (Id.)

As of mid-1978, Chemical still had at Water Street 78 IBM 3330s which had not been replaced by STC or by IBM's 3350 drives. (Tr. 74866.) The 3330s offered the flexibility of permitting the movement of disk packs and hence data from one drive to another. (Tr. 74866-67.) The 3350s, however, offered over 50% more storage capacity than the 3330-11s and, because of their non-removable media design, more reliability and freedom from dust "contamination . . . a serious problem in the accuracy of recording data". (Tr. 74861.)

Forty-eight STC 3670 tape drives. These devices, which store data at a density of 6,250 bits per inch of tape, were installed in 1976. They had replaced some number of lower density, 1600 bits per inch, STC tape drives which were installed in late 1973, and early 1974, replacing IBM tape drives. (Tr. 74815, 74824.)

In 1978, Welch had on order an IBM 3850 mass storage device which he anticipated would replace 20 of the STC tape drives. (Tr. 75253-54.) Welch described the 3850 decision:

> "It is a cartridge-oriented device that will allow us to reduce our library of 27,000 tapes, we believe, to approximately 5,000. It will allow us to substantially reduce our library support work force, but the most important element in my

> opinion . . . [is] that it should significantly minimize our opportunity to make errors on the mounting of incorrect tapes." (Tr. 75254.)

<u>Eight IBM 3211 printers and two IBM 3800 printers.</u> Chemical was in the process of "converting" a good deal of its printing work from the 3211s to the 3800s. (Tr. 74980-81.) Welch compared the two products by explaining:

> "In the case of the 3211, in order to accomplish the function of printing, instructions were written by a programmer and operated on literally by the CPU. Whether it be a 3168 or a 3158 or, for that matter, I guess any other CPU, that caused the printer to line things up, to do things the way that the application of the user demanded.
>
> "In the case of the 3800, at least some of that--some of those instructions are in fact included in the 3800 itself. As a result, there is less need for the central processing unit identified as [the] IBM 3168 in our case to deal with, to use up its time in performing activities relative to printing, at least some activities relative to printing." (Tr. 75102.)

The 3800 printers were installed in December 1977 and February 1978 (Tr. 74980), after consideration of printers offered by Xerox and Honeywell. (Tr. 75256.)

<u>IBM 3705 communications controllers.</u> These devices were installed in pairs, with one functioning as "back-up" for another. (Tr. 74877-78.) The 3705s were installed in late 1975 or 1976. (Tr. 74886.) By mid-1978, however, Chemical was considering replacing several of them with communications controllers supplied by Comten. (Tr. 74885-86.) Welch explained the reasons for considering this

option:

> "[W]e are looking to replace some of those 3705s by Comten units, and the purpose of that is that we are concerned about how to deal with the branch terminal system when the main computer, the large 3168[*] or 158 goes down. We would like the teller at the teller station not to be aware that the large mainframe is down at least for most of their transactions.
>
> "One of the reasons for being interested in the Comten communications controller is that it enhanced our ability to put a file, a disk file, of certain data directly attached to the Comten unit and therefore, if the 3168 went down, we could get at some of the files through the communications controller.
>
> "So again, there are trade-offs, and what we are constantly trying to do is to decide how we can use the equipment we have or change it, for that matter, to make the system more reliable.
>
> "I am not suggesting that if the 3168 went down we could do all of our business through the Comten unit, but we believe we could keep most of the tellers in business for most of their activities by in fact hanging a disk file off the Comten unit." (Tr. 75489-90.)

<u>A Collins C-900 configuration.</u> Although supplied with software by Collins, a division of Rockwell International, this configuration actually consists of two DEC PDP 11/35 processors, two DEC PDP 11/05 processors, CalComp disk drives, Cipher tape drives, Documation and Data Products printers and a Texas Instruments console. (Tr. 74940-48, 75078-81.) As described below (see pp. 1359-60), in mid-1978 Chemical was in the process of integrating the Collins equipment into its

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* 3168 is IBM's model number for the 370/168 processor.

main system to perform "message processing" and "general business processing" in connection with various funds transfer applications performed by the bank. (See Tr. 74942, 74944-45.)

Two Data General Nova 1200 processors and associated peripheral equipment, including approximately 150 Data Source terminals located at retail stores. (Tr. 75033, 75039-40.) The Data General systems are used in performing Chemical's Mastercharge application. (Tr. 75032-33.)

A variety of terminals, connected to the equipment in the "main computer system" by cable and communications lines. The terminals located at the Water Street center are supplied by IBM, Burroughs, Docutel, Four Phase and Bunker Ramo. (Tr. 74949-50, 74963-65, 74972-79, 74984-85, 74994-96.)

At another data processing center, this one in Lake Success, New York, Chemical had additional equipment which was also part of its main computer system. At Lake Success there was an IBM System/370 Model 158 CPU, STC tape drives, IBM disk drives and Four Phase System IV/70 processors with associated CRT terminals. (Tr. 75073-76.)

At still other locations, Chemical had additional equipment installed which was also part of its main system. That equipment included: over 150 Data Source terminals, as just noted, located at retail stores (Tr. 75033); additional Four Phase System IV/70 equipment at a smaller Chemical data center in Melville, New York (Tr. 75043, 75072); Bunker Ramo terminals in approximately 35

Chemical branches, with plans for the ultimate installation of 1500 such terminals at branch locations to perform teller banking functions (Tr. 74852, 75126-27); Docutel automated teller machines at various Chemical branches, to perform "do-it-yourself" banking functions (Tr. 74972-74); and Hazeltine terminals at Chemical's "upstate" banks, performing data entry and some processing in connection with customer account activity at those banks. (Tr. 74889-91.)

In addition to Chemical Bank's "main computer system", the bank had a number of stand-alone systems dedicated to the performance of particular applications. These systems, like the "main" one, evolved through the 1970s as the bank's approach to its overall data processing operations changed. One such stand-alone system is what Welch described as the "Central Funds Organization computer system". (Tr. 74790.) The system includes three Burroughs B 4700 processors. (Tr. 74790-91.) The B 4700 was introduced by Burroughs in 1971 as the "top" of its "medium-scale" computer line. (DX 3269, p. 4.) In addition to the B 4700s, the system includes eight 1600-bit-per-inch Burroughs tape drives, and twelve Burroughs disk spindles (with physically integrated controllers). (Tr. 74795-97.) Chemical installed the B 4700 processors in 1974. (Tr. 74802.)

The Central Funds system performed a data entry, capture and organization function in connection with Chemical's processing of checks for its customers' accounts. (Tr. 74792-93.) The remainder of the check processing work done domestically is performed on Chemical's main system. (Tr. 75046-47, 75122-23.) In 1978, Chemical was "seriously interested" in converting from the B 4700s to an IBM 370/158. (Tr. 75522-23.) Welch testified that he would make the conversion "if it is cost effective" and continued, "we believe at the moment that it may very well be cost effective" to do so. (Id.)

The operation and interrelationships of all Chemical's EDP equipment, both in the "main" system and the stand-alone systems, are quite complex, as can be seen from an analysis of Chemical's demand deposit accounting application, called DDA, the bank's "largest single application". (Tr. 75429.) DDA involves the processing of transactions for customer checking accounts. (Tr. 75119.) In processing the DDA applications, Chemical uses much of the equipment in its main computer system as well as Burroughs and NCR "MICR" (Magnetic Ink Character Recognition) equipment (Tr. 75120-21), the "Central Funds Organization" system (Tr. 74790-93), some of its Four Phase System IV/70 equipment (Tr. 75121), IBM System/3 and Hazeltine equipment in Chemical's "upstate" banks (Tr. 75121, 75127-28), a variety of DEC and Hazeltine equipment installed at various Chemical locations in Europe (Tr. 75123, 75137-40), "COM" (Computer Output Microfilm) equipment (Tr. 75125-26) and Bunker Ramo terminals installed at various Chemical branch offices. (Tr. 75126-27.)

The DDA application involves three basic stages:

(1) reading data from checks and entering the data into the system, (2) updating customer accounts to reflect checking transactions, and (3) output of data reflecting transactions and the updated status of customer accounts. (Tr. 75119-20.) At different geographic locations, the bank performs each of the stages of the DDA application in different ways. Thus, in New York City, input of data from checks is accomplished by NCR, Burroughs and Four Phase equipment. (Tr. 75119-21.) In the "upstate" banks, this portion of the DDA application is performed on IBM System/3s (Tr. 75121); and in Europe, it is done by using CRT terminals connected to DEC PDP processors. (Tr. 75121-23.)

In New York City, capturing of check data by customer, by bank and the like, as part of the initial stage of the DDA application, is performed by Chemical's "Central Funds" system (Tr. 74790-93); the upstate banks use IBM System/3s (Tr. 75121); and the European locations use their DEC equipment with software supplied by Arbat. (Tr. 75121-23, 75137-40.)

The second stage of the DDA application, the processing of checking account transactions, is done in New York City by Chemical's main system, using IBM 168 and 158 processors. (Tr. 74826, 75122-24.) For the upstate banks, this processing is also done by the main system, with data accumulated by the System/3s electronically transmitted to New York City for account processing. (Tr. 75123-24.) In Europe, the DEC processors perform this function. (Tr. 75123.)

The output stage of the DDA application in New York City is performed in four different ways: by printing account reports and physically delivering those reports to the branch offices each day; by capturing account status information on microfiche using COM equipment; by transmitting the data directly via communications lines to Bunker Ramo terminals installed at Chemical branches; and by communicating the data to IBM cash management system display devices. (Tr. 75125-27.) The upstate banks receive their DDA output by telecommunication transmissions from New York City to Hazeltine terminals at the upstate locations. (Tr. 75127-28.) In Europe, the DEC Systems use CRT terminals and also have hard copy printing capability. (Tr. 75137-40.)

b. Chemical's major EDP procurements. Throughout the 1970s, Welch and his staff made procurement decisions to meet changing application needs, changing the configuration of the bank's main system or installing separate systems or equipment to perform all or part of the additional application load. In these procurement decisions, the bank's data processing personnel made choices from among a range of alternatives, in order to reach what in their view was the most cost-effective solution. That analysis and procurement process is an ongoing one. Welch testified that there are at various times from 50 to 60 Chemical employees "whose primary function is to evaluate and reevaluate both the things we are currently doing and those devices or software products that are being proposed by others". (Tr. 74717.) Welch seeks "the most cost effective method" of satisfying Chemical's data processing needs (see Tr. 75501), and he believes that "at any point in time we have attained the best that we know how to do in cost effectiveness". (Tr. 75653.)

The procurement decisions of Chemical Bank may be broken into roughly three categories, for purposes of this discussion.

The <u>first</u> category includes those decisions involving significant equipment and programming changes to the existing main computer system. Many of these decisions have already been discussed. (See pp. 1342-51 above.) The overall capacity of the main system wa enhanced and enlarged in major ways, through the addition of newer equipment, including larger processors, additional memory, newer disk and tape subsystems and newer printers, to name but a few. In addition there were three procurements of some significance.

(i) <u>Branch terminal system.</u> Beginning in 1974, Chemical undertook to implement a branch terminal system, providing tellers with terminal devices connected to the central Water Street installation. (Tr. 75210-21.) Such a system would enable individual tellers to inquire, in an on-line mode, into the current status of customer accounts and to perform other tasks, such as placing "stops" and "holds" on accounts or particular transactions. (See Tr. 74969, 75216.) The system, then, as envisioned, would permit input and output to be performed at, and processing to be directed from, locations remote from the bank's main computer equipment locations.

Initially, Chemical and IBM undertook a joint project called "Rainbow", which involved the installation of IBM 3600 terminal systems at 20 branches for a period of 15 months. (Tr. 75210-13.)

At the end of the 15 month period, however, the IBM equipment was removed because, in Chemical's view, the costs of the equipment exceeded the benefits to the bank. (Tr. 75213-14.) Welch explained that:

> "After the removal of the IBM 3600 series, we continued terminal evaluations because it was the desire of our user, the Metropolitan Bank, to get a very inexpensive terminal as opposed to the relatively expensive 3600 . . . ." (Tr. 75257.)

In 1977, Welch received bids from six vendors for the proposed branch terminal system: Burroughs, Incoterm, IBM, Bunker Ramo, NCR and Datatrol. (Tr. 75258-59.) Welch described NCR's proposal: a stand-alone network of branch terminals, automated teller machines and point-of-sale terminals linked to four to six Criterion series processors. (Tr. 75259, 75283-84.) After NCR announced the sale of a similar system to Manufacturers Hanover Bank, Welch spent two days at NCR's offices examining their equipment but, in the end, decided it "was not a cost effective solution". (Tr. 75283-84.)

The bank's in-house evaluation group narrowed the field to two: IBM, bidding a "revised" 3600, and Bunker Ramo. (Tr. 75257-59.) Ultimately, Bunker Ramo, whose products offered less function but cost less, was selected. (See Tr. 75259-61.) The Bunker Ramo equipment cost $3 million as compared to IBM's $3.4 million. (Tr. 75263.) Bunker Ramo's sale to Chemical was one of several successful marketing efforts of its "Bank Control System 90" during 1977, according to the Bunker Ramo 1977 Annual Report. (DX 12284, p. 5.) Among the other banks acquiring this equipment were the National Bank of Detroit, the Arizona Bank and U.S. National Bank of Oregon. Bunker Ramo further reported that its 90 System equipment was installed with customers ranging "from the Bank of America's more than 1,000 branch offices to the National Bank of Fort Smith (Arkansas) with three offices. Bank Control System 90 hardware now is operating in nearly 2,000 banking offices. . . ." (Id.) According to Bunker Ramo, its 90 System hardware, as well as Diebold-manufactured automatic teller machines and cash dispensers, provided the company with "a good entry in the field of electronic funds transfer systems"--estimated to be more than a billion-dollar business between 1978 and 1983. (Id.)

Chemical Bank's decision to acquire Bunker Ramo branch terminal equipment was made on the basis of cost-effectiveness: "in order to decide on cost-effectiveness, you had to decide whether in fact you wanted" the additional function that the IBM equipment offered for the extra cost. (Tr. 75260-61.) Chemical decided it did not want the additional function.

(Tr. 75261.)

As of mid-1978, approximately 20 branch offices were "on-line", with plans to bring up the remaining branches in the ensuing months. (Tr. 74967-68, 75217.) The branch configuration consists of Bunker Ramo 90/17 and 90/11 terminals connected to Bunker Ramo intelligent terminal controllers. (Tr. 74966-68.) Bunker Ramo's controller, or "Programmable Control Unit" (PCU), is described by the company as:

> "a powerful minicomputer expandable from 16K to 64K bytes of memory . . . . The PCU provides processing logic, display refresh, device control, memory, and communications interface functions for all display and peripheral equipment. Modular design permits the addition of a more sophisticated peripheral such as a diskette storage device." (DX 14478, p. 2.)

In Chemical's system, the Bunker Ramo PCUs are in turn connected to IBM 3705 communications controllers at Water Street, and then to the large IBM processors in Chemical's main system. (Tr. 74920.) In addition, the bank installed Docutel automated teller machines for "do-it-yourself" banking transactions. (Tr. 74876, 74972-74.) Further plans included use of the Bunker Ramo PCUs to store and process data concerning each branch's customer accounts--thus enabling the PCUs to respond to teller inquiries that otherwise would be handled by one of Chemical's 370/168s. As Welch explained:

> "[O]ur concept there is to put in a branch as much information about that particular branch's customers as we can to minimize the communications

effort required to come back from every branch to the main system." (Tr. 75238-39.)

(ii) Funds Transfer. Chemical performs a set of applications, which are known as "funds transfer". (Tr. 74941-42, 75301.) This activity includes keeping records of funds transferred between customer accounts and between banks. (Tr. 75178-79.) Some portions of the bank's funds transfer work, however, were not automated. (Tr. 75179-81.) As to those portions which were automated, Chemical decided to move the funds transfer application from its main system, where the application had been performed by a 370/168. (Tr. 75301.)

Chemical set up an internal study for the purpose of deciding "how many of the different ways by which we transferred funds we might automate". (Tr. 75179.) After studying the problem, Chemical issued a request for proposal to which, Welch believed, five vendors, including IBM, responded. (Tr. 75179-80.)

IBM initially proposed implementing funds transfer operations on a System/7. (Tr. 75180.) Chemical did not think "that solution was satisfactory, and they [IBM] came back with a second proposal and said they would solve it via an IBM 138". (Id.) Qantel also made a proposal--Chemical "almost adopted" it, but the user portion of the bank "wanted to add some functions to a package Qantel already had, and they couldn't handle it". (Id.)

Chemical then selected Collins, another respondent to the request for proposals. (Tr. 75180-81.) Collins was selected, according to Welch, because "in addition to the apparent cost benefits of the equipment", they proposed what was in Chemical's view an ambitious plan for funds transfer automation. (Tr. 75181.)

The Collins C-900 equipment was described above. (See p. 1349.) As of mid-1978, this equipment was in the process of being installed as an addition to Chemical's main computer system. (Tr. 74942.) Chemical's initial plan for the Collins equipment was to use it "in many applications as a message processing device". (Tr. 74944.) However, as work on the installation progressed, Chemical decided that "in addition to the communications processing we would do what I could call application processing; that is, we would take problem programs on funds transfer and actually have them processed within this unit". (Tr. 74944-45.) Thus, it was decided that, in addition to automating certain funds transfer work for the first time, portions of the bank's funds transfer processing would be "remove[d] . . . from the 3168 [370/168] to the Collins C-900". (Tr. 75301.)

<u>A note on other banks</u>: The data processing function of handling message switching, which, as noted, was among the functions to be performed by the Collins equipment at Chemical Bank, was a common function performed by banks in the 1970s in

connection with their funds transfer activities. There are many alternative ways to perform the message switching function in addition to those which Chemical chose to consider. Withington testified that various banks have chosen to do it in different ways, using different data processing equipment. In connection with a 1972 study that Arthur D. Little performed for Collins Radio, Withington obtained information on the systems used and the alternatives considered by several banks in the Federal Reserve System for performing message switching. In 1972:

(a) The Federal Reserve Bank of Boston evaluated proposals from several potential suppliers, including IBM, Burroughs, Comten, Western Union and Honeywell. Eventually they decided to procure a Burroughs 3500 system (the same type of computer used by Chemical for check processing data entry and capture prior to upgrading to Burroughs B-4700s). (Withington, Tr. 57539-41.)

(b) The New York Federal Reserve Bank had installed a "network processor", ICS 500, based on the Xerox Sigma 5 system, and was using a software package developed by Informatics. (Tr. 57540.)

(c) The Federal Reserve Bank of Chicago had installed a Control Data 1000 "network processor". (Id.)

(d) The San Francisco Federal Reserve Bank had an IBM 360/50 computer system "dedicated to this message switching application". (Id.)

(e) The Federal Reserve Bank of Kansas City had under consideration an IBM 370/165 computer system for partial dedication to the network processing function. (Id.)

(f) The Federal Reserve Bank of Minneapolis "used a Honeywell minicomputer programmed and equipped as a network processor". (Id.)

(g) The Federal Reserve Bank of Richmond "considered a Comten 620, a system designed for this purpose". (Id.)

(h) The Federal Reserve Bank of Atlanta had under consideration a Marshall 1000. (Tr. 57540-41.)

(i) The Federal Reserve Bank of Philadelphia "had a specially programmed" IBM 1130 computer system. (Tr. 57541.)

(j) The Federal Reserve Bank of Cleveland had two IBM 370/135's "dedicated to the message switching application". (Id.)

(iii) Trust and Investment. The third "procurement", unlike the preceding two, involved the replacement of installed, stand-alone systems with software added to Chemical's existing main computer system.

Chemical has for many years maintained a Trust and Investment section. (Tr. 75182.) For some time prior to 1976, the bank used several Burroughs B-300 processors, "another device that was manufactured by Univac", and associated EDP equipment to perform its trust and investment applications. (Tr. 75193-94.) In 1976 that equipment was replaced by two newer Burroughs processors, B-2700s, and associated peripherals. (Id.) Yet the bank's Trust and Investment section wanted improved EDP service, "to provide to its customers a more efficient and therefore more informative system". (Tr. 75185.)

Chemical's Trust and Investment section, with an outside consultant, engaged in an analysis of available options and ultimately decided to replace the Burroughs B-2700s with a software package acquired from Mellon Bank to be run on Chemical's main system, with processing done on a 370/168. (Tr. 75184-87.) Welch described the decision-making process as follows:

> "So we decided to look at what was then called the Trust and Investment long-range plan and decide how the bank wished to conduct at least that portion of the trust and investment business regarding information.
>
> "We searched--well, for a long--we hired an outside consultant and tried to identify those issues that trust and investment people wished to deal with, and that was done over a period of almost two years. A large set of what I would call -- the bank would call -- the data processing people would call specifications were prepared. They consisted literally of five books, and said this is the way we want to conduct our trust and investment business.
>
> "At that period of time the head of the Trust and Investment Bank said to the officer directors, 'We want to go forward with a long-range plan. We

> want this kind of activity, here is what we think it will cost. Will you please give us approval?' And we obtained it.
>
> "Then we decided that maybe instead of doing this all ourselves, we would find that other banks have done it because obviously other banks are in the trust business. After looking around several banks and evaluating several packages, we chose one offered by the Mellon Bank." (Tr. 75185-86.)

The Mellon Bank software package was purchased by Chemical and by Bankers Trust. (Tr. 75186-87.) Chemical first began testing and modifying the software in the spring of 1977, and in June 1978 was still doing so; it did not expect to complete the process until late 1978. (Tr. 75187-88.) Mellon's software was designed for "batch" mode performance. (Tr. 75187.) As Welch explained, "that is, the information processing [is] done fundamentally on an overnight basis". (Id.) Welch elsewhere described "batch mode" as "the accumulation of input material, the entry of it at one time, being a point in time, and the output of it in some time frame as opposed to continuing". (Tr. 75313.) Chemical, however, wished to perform the trust and investment application in a "real time" mode (Tr. 75187): "[T]he kind of computer activity which accepts an entry at the time it's made . . . creates a new record or adjusts an old one, changes an old one, perhaps, and is capable of responding to the person who inquired in for all practical terms immediately, but in a time frame of perhaps three seconds to five seconds, at least desirably". (Tr. 75314.) Although Mellon Bank used its software package on the same type of computer Chemical planned to use (an IBM 370/168) the conversion of the software to run in a "real time" rather than "batch" mode had taken over a year, and would ultimately require about a year and a half to complete. (Tr. 75186-88.)

A <u>second</u> category of procurement decisions involved selecting smaller stand-alone systems as an alternative to performing the applications on the bank's existing main computer system. These decisions included the following five:

(iv) <u>Foreign Exchange Trading.</u> Foreign exchange trading is an application first performed by Chemical on a computerized basis in 1977. Prior to that time, this work was done manually. (Tr. 74903.) Chemical implemented a computerized system designed to support the activities of employees of the bank who buy and sell foreign currencies on international currency markets for the bank and its customers. (Tr. 74896-97.) It is necessary, in support of such activities, to create a variety of accounting records reflecting the results of currency transactions. (Tr. 74901.)

In mid-1977 Chemical acquired a stand-alone system and proprietary software to perform the foreign exchange trading application. The system consisted of 2 DEC PDP 11/50 processors, 16 Hazeltine CRT terminals at Water Street and additional units in the Foreign Exchange Trading department several blocks away, a DEC Writer II printer (at Water Street) and a Xerox printer (at the trading department), and DEC disk drives for data storage. (Tr. 74896-98, 75635-36.) The hardware and application software was acquired as a package from Arbat. (Tr. 74906, 75634-36.) Although this particular Arbat-supplied system was used by Chemical only for its foreign trading work, Arbat apparently offered a much broader line of services. According to one industry trade press account, "Arbat can automate an entire international bank including loans and deposits, all accounting, commercial banking and foreign exchange for about $1 million . . . ." (DX 14231; see also DX 3678, p. 1.)

In mid-1978 the Arbat-supplied system was stand-alone: it was not electronically connected to Chemical's main computer system. (Tr. 74900.) The Arbat system, after processing the foreign exchange information, created tapes containing the resulting accounting records which were "capable of being transferred to run on the . . . IBM 3168 [370/168] equipment". (Tr. 74901.) Chemical was, at the time, manually transferring the tapes to the main system for related applications work performed there. (Id.) The bank had plans, however, to "make an electronic conversion at a point in time"--that is, to transfer data from the Arbat to the IBM equipment via electronic means rather than by manually carrying magnetic tapes from one system to the other. (Tr. 74900-01.)

Welch testified that the foreign exchange application could have been performed on Chemical's main system with processing done by 370/168s and a 158. (Tr. 74904.) Alternatively, the application could have been performed on computers of "similar size and capability" to the PDP 11/50s manufactured by other vendors (Tr. 74902-06) or on IBM System/3s. In fact, Chemical had at one time planned to implement the application on System/3s installed at various Chemical European locations. (Tr. 75152-57.) The hardware and software was acquired from Arbat, however, because that seemed to be "the fastest way to get that application implemented". (Tr. 74902-05.) Arbat already had a foreign exchange trading package developed for use on DEC equipment. (Tr. 74904-05.)

(v) Legal Department. Another application first implemented in 1977 was for Chemical's Legal Department. (Tr. 75194-95.) As Welch described the application, it was

> "best . . . called a filing system . . . in which the lawyers enter in case identifications, and . . . case summaries and . . . are capable of retrieving information about case loads, by lawyer, . . . by the dates in which they have to appear in court, and a variety of other subjects . . . ." (Tr. 75195.)

To perform that work, Chemical acquired as a package a stand-alone system consisting of a DEC PDP-8 processor, a CRT terminal, a disk drive and a hard copy printer, as well as the necessary application software. (Tr. 75195-97.)

As an alternative, Welch considered implementing an IBM program product known as STAIRS to run on Chemical's main computer system. (Tr. 75196.) He described the procurement decision as follows:

> "I brought a couple of lawyers from the Legal Department to see that demonstration [of STAIRS], and they liked it, felt that it did everything that they wished, and a little bit more in some cases. And I assigned a programmer to determine whether we could and/or should implement STAIRS on one of our large mainframes, and the net result of that was that the implementation of STAIRS would have been more expensive than the Legal Department felt was warranted, and we found another, a software package again . . . [which] came or was prepared by the software firm to run on a PDP-8. So we acquired the package and the equipment concurrently cost, considered at least by the Legal Department, significantly lower than would have been incurred had we place [sic] that package in the . . . main New York computer center." (Tr. 75196-97.)

(vi) Fixed Asset Accounting. In mid-1978 Chemical had plans to implement a fixed asset accounting application on an IBM 5110 computer system. Welch described the application as "keeping track of fixed assets, not only computers but desks, chairs and other things that the bank would acquire and consider as a fixed asset". (Tr. 75198.)

Prior to deciding on use of the 5110 for this work, Chemical considered "at least two other choices". (Tr. 75198.) First, Chemical considered acquiring a fixed asset accounting software package from Management Sciences of America (MSA). (Tr. 75198-99.) The software would have been "integrated" by MSA into existing accounting software already run by Chemical on its main computer system. (Tr. 75199.) However, Welch explained, "in line with a policy that I have established of trying to avoid putting what I refer to or call a small job into that main computer system, I felt that we should not try to add that kind of work into the main computer system. As a result, we then tried to find a package which would run on some other piece of equipment". (Id.)

MSA then assured Chemical that their fixed asset software would run on a "smaller" system, specifically a 370/138 already installed at the bank's Control Division. (Id.) But Welch explained:

> "We elected not to do that, primarily because we weren't satisfied that this fixed asset package being offered entirely met some of the needs that we had, and also because we wanted to get some experience in programming on a computer the size of the 5110. So for the two reasons, one being that I did not want to add that size to that small sized application, and the second being that I wanted to get some experience in handling a smaller computer, we elected to try to implement that activity on an IBM 5110." (Tr. 75199-200.)

(vii) Bond Trading. Chemical performs a bond trading application in which the bank's investment personnel buy and sell bonds for the accounts of customers and of the bank. (Tr. 75280-81.) The bank investment personnel asked Welch's group "to develop an application whereby their work in process that is, the transactions that they had initiated, would be electronically accumulated and a position status be maintained on a current basis". (Tr. 75281.)

Welch initially considered installing terminals in the bond trading department, located several blocks from the main computer center, linked into Chemical's main computer system. (Id.) In the process of implementing that approach, however, Welch discovered that the cost of communications between the two locations combined with the cost of devoting time on Chemical's main system to do the bond trading work would "exceed the cost of a small general purpose computer". (Tr. 75281-82.) As a result, Chemical "engaged a software company to write for us the application and, in fact, installed it in [the bond trading department] using Interdata 7/32 computers". (Tr. 75281.) The Interdata system cost $70,000-$80,000; the "line cost and related assessment of the CPU costs [on Chemical's main system] would have exceeded $100,000". (Tr. 75282.)

(viii) Personnel. The final procurement in this area was not yet completed at the time of Welch's testimony. (Tr. 75278-79.)

Welch's department performed a personnel application for the bank--the maintenance of "records of employees and names and various and sundry personnel information". As of the time of Welch's testimony, that application was still being run on Chemical's main computer system. (Id.) At the time, however, the bank was considering two options for off-loading that function from the main system. As Welch described the alternative evaluation process:

> ". . . We are investigating two alternatives to removing that application from the main computer center.
>
> "One is with a service bureau in New Jersey who has offered us a package program to be run on a small general purpose computer for which they would supply the programs, and another is to acquire a small general purpose computer, install it in the bank, and, in fact, in this instance, install it in the Personnel Department, and write program instructions using bank personnel.
>
> "It is the recommendation of the Personnel Department, and I supported it on Monday of this week, that we choose the latter route, namely, to install a small general purpose computer system -- I believe it is a Hewlett-Packard in this instance -- to remove that personnel data system from the main computer center." (Tr. 75279.)

The third area of procurements relates to a management decision by the bank to bring in-house a variety of applications that had been performed for the bank by time sharing services.

(ix) Bank investment and others. Chemical performs a "bank investment" application, involving the calculation of securities portfolios by Chemical personnel. (Tr. 75290-91.) The bank investment application, as well as a variety of other applications, was for some time performed for Chemical by a number of outside time sharing service vendors. As of mid-1978, Chemical used approximately 20 to 30 such vendors, including GE, Interactive Data Corporation and Computer Time Sharing. (Tr. 75289-90, 75291, 75293.)

About two years prior to Welch's testimony, Chemical's senior management asked Welch to investigate means of reducing Chemical's expenditures for time sharing services--totaling approximately $2.5 million per year. (Tr. 75290.) As a result of that analysis, Welch's group "determined that at least one-third of the total time sharing applications are of a type that could be easily converted to an in-house use and that value is now approximately $800,000 to $900,000 a year, which is great enough to support an internal time sharing computer". (Id.)

As a step toward achieving the targeted cost savings, Chemical in 1977 contracted with Computer Time Sharing (CTS). (Tr. 75290-92.) That agreement provided that certain applications performed by various time sharing vendors on various computer systems would be transferred to CTS which would then perform those applications on a Honeywell 66XX system for two years, at a 25% cost reduction to Chemical; that CTS would, at no additional cost to Chemical, do any conversions necessary to run the applications on the Honeywell equipment; that at the end of two years, Chemical would then install a Honeywell system and bring the performance of the applications in-house; and that CTS would supply Chemical with the applications software, again at no additional cost. (Id.)

As of June 1978, CTS had converted the "bank investment" application and was performing it for Chemical. (Tr. 75291.) Also by that time, CTS had taken over a mortgage analysis application previously performed for Chemical by GE Time-sharing Services; in that case, there was no conversion needed because GE had been using Honeywell equipment. (Tr. 75293-94.)

Welch noted that he planned ultimately to shift some in-house time-sharing work done on Chemical's main system, using its IBM 370/158 processor, to the Honeywell equipment. (Tr. 75294-95.) With respect to those plans, Welch explained:

> "We have -- we, in fact, are incurring a history by which our data processing activity grows at the rate of approximately 20 percent per year, 'our,' being the Information Services Group, and I personally would expect that the growth, which is occurring primarily in ad hoc requests, would be the kind of -- would be the type of application that I would like to experiment with in a new probably medium-sized but yet unidentified Honeywell 66XX device." (Tr. 75295.)

78. American Airlines. Three witnesses have testified concerning the data processing operations of airlines. The most extensive testimony came from James J. O'Neill of American Airlines, but there is also testimony in the record from Frank Heinzmann, Data Processing Vice-President at Eastern Airlines, who testified at the trial of Telex v. IBM, and from James Welch, who also testified at the Telex trial and who, before moving to Chemical Bank, was in charge of data processing at American Airlines.

Mr. O'Neill, Vice-President of Data Processing and Communications Services for American Airlines, testified in late June and early July 1978 concerning the data processing operations of American. He has been involved in data processing since the late 1950s and prior to joining American in 1973 was, for approximately three years, a Vice President for Reservation Data Processing at TWA. (DX 3680.) Among his professional activities, Mr. O'Neill has served on a number of data processing and communications committees of air transportation industry organizations and is a member of the Society for Management Information Systems. (Id.)

a. The Growth of American Airlines' Computer System. American Airlines' demand for data processing capacity has greatly expanded over time. (See e.g., Tr. 76706-25.)* And as is clear

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* Unless we note otherwise, the transcript references in this section refer to Mr. O'Neill's testimony.

from the following discussion, American has continually added processing, input/output and storage capability to its system to meet the ever increasing demand. O'Neill described that process as "buy[ing] boxes", as opposed to computer systems, so that American "can put together the pieces and pick and choose the best boxes at the lowest cost from the various manufacturers that are offering those boxes".* (Tr. 76249.) With each procurement decision, American substitutes or adds boxes to its system. O'Neill explained that American can

> "acquire either the services or the equipment necessary to do a specific job from a number of different manufacturers. I can do that either by substituting equipment on a box-for-box basis or I can do that by taking a different approach to the problem.
>
> "A case in point is today we could substitute memory, we could substitute processors, we could substitute tape drives, we can substitute disk drives, we can substitute printers, we can substitute different smaller disbursed processors, all from a variety of different manufacturers who apparently are making money at it." (Tr. 76236-37.)

American has in fact achieved increased capacity through a combination of means.

(i) American Has Upgraded the Central Processing Units in its System. Taking American's on-line reservation application

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* O'Neill testified that American had approximately 20 employees "pretty much full time engaged in the analysis of data processing products and services". (Tr. 75691.) In addition to analyzing available alternatives, the group receives input from American's data processing staff, identifying application and capacity needs, and "convert[s] it to an equipment plan; in other words, what equipment is required to satisfy that need." Based upon that equipment plan they then "develop specifications for the equipment." (Tr. 75693-94.)

as an example (see generally, Tr. 75731, 75862-64, 75990-76005; DX 4109: Welch, Tr. (Telex) 2931-32), the airline first implemented that application in the early 1960s with two IBM 7090 processors. In the mid-1960s the 7090s were upgraded, through the addition of main memory capacity, to 9090s. In the late 1960s American added two System/360 Model 65 central processing units as front-end processors to the 9090s. In 1972 the Model 65s replaced the 9090s and three Collins 8500s were added as front-ends. Since then, the Model 65's have been replaced for passenger reservation processing by a System/370 Model 168 and an Amdahl 470 V/6; the Collins 8500s are still installed.

(ii) <u>American Has Distributed Much of its Processing.</u> Looking to the reservation application as an example, beginning in the mid-1970s and continuing to the time O'Neil testified, American added: 13 Texas Instruments 990 processors, 5 CCI CC-80 processors, a number of Raytheon PTS 100 processors, 5 ICOT 101 processors, 40 ICOT 275 processors and 6 IBM 3705s--all used, with American's IBM and Amdahl processors as well as the Collins 8500s, to carry the processing load for passenger reservations. (Tr. 75731-35, 75975, 75991-95.)

With the addition of those devices, and the large number of terminal, data entry, data output and storage devices located at hundreds of remote locations all around the country, by 1978 American had distributed much of its computing capability away from its "central site":

(a) the processors at American's main computer center in Tulsa, Oklahoma, accounted for less than 15 percent of the "MIPS" (millions of computer instructions executed per second) capability in the overall system (Tr. 76936);

(b) the "boxes" located at the central site represented fewer than 10 percent of the boxes in American's system (id.); and

(c) the equipment at the central site represented only slightly more than half of the purchase value of the entire American computer system. (Tr. 76936-37.)

The particular processors added by American to its system during the 1970s were, according to O'Neill, by no means the only options available. For example, he testified that in the early 1970s, a number of manufacturers, such as DEC, Data General and Wang "started to sell minicomputers that were direct substitutes for some applications being performed on the larger processors, which opened up a variety of other alternatives that weren't generally available earlier in the development of the industry". (Tr. 76245.) He added, "[T]oday there are a number of different ways that solutions can be developed to solve a problem." (Tr. 76246.)

(iii) American Has Expanded Its Storage Capability. Just by example, in 1972, American's on-line storage was contained on 20 2314 disks. (Welch, Tr. 74858-59.) By 1978 American had "several hundred" 3340 disk drives (Tr. 75732), and the 3340 had over 9 million more bytes of capacity per spindle than the 2314. (JX 38, p. 439; PX 4538.)

At the time O'Neill testified, American was considering a variety of options to deal with the fact that it apparently had inadequate memory capacity on its 168 and 470/V6 to support desired response times in various time-sharing applications. (Tr. 75825-26.)* The alternative solutions then under consideration included:

(a) a larger processor (Tr. 75826, 76078-79, 76241-42);

(b) more memory on the existing processors (Tr. 75826, 76078-79);

(c) IBM 2305 drum storage devices (Tr. 75826-27, 76078-80, 76241);

(d) off-loading up to 60% of the processing involved on remote, smaller processors--with proposals having been submitted by: IBM (Series 1), Raytheon and Incoterm (Tr. 75828, 76081, 76098-99, 76241-42, 76977-79, 76986-90, 77067-68);

(e) dedicating a smaller processor to time-sharing (Tr. 75829, 76241-42);

(f) additional disk devices (Tr. 76080); and

(g) IBM 5100 and 5110 processors. (Tr. 76081.)

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* O'Neill testified that some of American's time-sharing work was performed by using outside service bureau facilities. The volume of that activity was decreasing as American did more time-sharing work in-house. (Tr. 76081-82.)

Significantly, although American's data processing capacity has substantially increased in the 1970s, the value (on an original price basis) of that capacity has remained essentially the same. In 1973 Welch estimated that value at approximate $90 million. (DX 4109: Welch, Tr. (Telex) 2920.) In 1978, O'Neill estimated it at $110 million. (Tr. 76937.)

b. The Growth in the Number of American's EDP Suppliers. Through the 1960s and into the early 1970s, American was predominan ly an IBM customer. (Tr. 75862-63, 75928-29, 75990-93, 76207-13, 76763-64.) Even in 1978, American had a great deal of IBM equipmen installed, for the most part at its main data processing center in Tulsa, Oklahoma: two 360/65s, three 370/168s, several hundred 3340 disk drives, about one hundred 3420 tape drives and six 3705 communications controllers, among other equipment. (Tr. 75731-32.) But in the 1970s, the offerings of many more vendors were incorporated into American's system. By mid-1978 the system contained products from more than 25 vendors, including: IBM, Amdahl, Memorex, Collins, CCI, Texas Instruments, CalComp, Raytheon DEC, ICOT, Incoterm, GE, Centronics, CDC, Data 100, NCR, Hewlett-Packard, REI and Four Phase. (DX 3681.) Moreover, American was using "approximately two hundred different software products" acquired from third parties, including: Arthur S. Kranzley, Whitlaw Associates, Boole & Babbage and DACOM. (Tr. 76125-27, 76214.)

As a result, by mid-1978, "less than five percent of the total MIPS capability" of the system was IBM-manufactured. (Tr. 76938.) And, as noted above, American's central site--where most of its IBM equipment was installed, as well as substantial amounts of equipment from Amdahl, Collins and others--had come, by 1978, to represent a small percentage of the boxes in the system and little more than half the purchase value of the system. (See p. 1377 above.)

c. <u>Implementation of American's Passenger Reservations Applications.</u> The changes in American's system are in part illustrated by focusing on the company's major application area--passenger service--and, particularly, on the EDP configurations used over time to perform the on-line reservation application known as "SABRE".

Frank Heinzmann of Eastern Airlines offered a brief description of the reservation application:

> "The most common situation would be where a customer called us on the telephone anywhere in the United States; we have over ten regional offices and approximately 2,000 girls on duty; and when they answer that phone here, the main input device to the computer system is a CRT type terminal that involves a television tube and a keyboard. They then communicate with the computer and probably the first question you would ask as a customer is what flights do you have available on a certain time of day to a certain destination, and she keys that in exactly in that fashion without reference to a schedule. The computer then translates that into a matrix of a schedule look-up statement checking the inventory of flights to determine what best four flights serve the customer's requirement. This is then recommunicated back through phone lines to the girl on a visual display. She then normally would select the appropriate flight that suits the customer, indicates that, hits a button that says, 'Sell that.' This is again transmitted back to the computer in Miami, updated on the files, and as the conversation goes

on, she picks up other indicative information, such as his name, his various phone contacts, does he have a hotel requirement, U-Drive It requirement; he may have special service requirements like meals, or any other associated activities with the flight itinerary. This normally, when the transaction was totally consummated, she hits a button that tells us this fact, and all this information was simulat and stored as one unique record in the system." (DX 5154; Heinzmann, Tr. (Telex) 3355-56.)*

American first implemented the SABRE reservation application in 1963. (See pp. 138-39 above.) It was the first airline to put in place a "passenger name record reservation system" (Tr. 76007), following a development effort which, according to O'Neill was "estimated to require about one thousand man years". (Tr. 76776.) American developed SABRE in a joint program with IBM, which, O'Neill testified, "played a major role in assisting in developing the SABRE system". (Tr. 76008.)

SABRE was from its beginning a complex data processing application. It is in many ways a large, complex inventory control program which keeps track of an airline's constantly shifting inventory of available seats, as well as destinations, costs, alternative routes and the like. It was, accordingly, quite difficult to develop. As we discussed above (pp. 477, 649), some other airlines--working with other EDP companies--were unsuccessful in the 1960s in their joint efforts to develop similar on-line reservation systems:

(i) In the 1966-67 time frame, TWA and Burroughs "attempted to develop a passenger service system utilizing

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* A more detailed description was supplied by O'Neill (Tr. 75713-15, 76005-07, 76023-26, 76577-79.)

Burroughs' 8300 processors". (Tr. 76014.) That effort was terminated in 1970 because, in TWA's opinion, the Burroughs system "could not accommodate the projected work load . . . and . . . had not demonstrated adequate availability or reliability". (Tr. 76015.) After terminating the project, TWA instituted litigation against Burroughs to recover its costs from the aborted program. (Id.) TWA then intalled IBM System/360 Models 65 and 75 processors for its reservation application and, in 1975-76, replaced those units with System/370 Model 168s. (Tr. 76013-17.)

(ii) Also in the 1966-67 time frame, United Airlines entered into a passenger service development effort with Univac. That effort, too, was terminated in 1970 when United "concluded that the system being developed by United at Univac would not accommodate their projected volume". (Tr. 76015-16.) United then installed IBM System/360 Model 65s for its reservation work and later replaced them with System/370 Model 195s. (Tr. 76016-17.) Despite its experience at United, Univac did successfully market on-line reservation hardware and software systems to Northwest and other airlines. (DX 5154, p. 3345.)

In addition to IBM's successful efforts at American, TWA and United, it also installed on-line reservation systems at Delta and Pan American and Eastern Airlines, among others. (See pp. 138-39, 477, 649 above; DX 5154: Heinzmann, Tr. (Telex) 3343-47.) Heinzmann of Eastern (and formerly of Delta) testified that Delta chose IBM over competitive proposals from Univac and Teleregister. (DX 5154 Heinzmann, Tr. (Telex) 3343-45.) He further testified that, after deciding to implement an on-line reservations system in late 1965, Eastern solicited bids from approximately 18 vendors, including: Univac, IBM, Bunker Ramo, General Electric, TRW and Burroughs. Th bids were received--from IBM, Univac and a joint proposal from GE, Bunker Ramo and Computer Applications, Incorporated. (Id., pp. 3350-51.) IBM proposed three 360/65 processors, large core storage (LCS) ("in lieu of" drum storage), disk files and 2915 remote terminals. (Id., p. 3352.) Univac proposed three 494 processors, "an assortment of disks and drums, other peripheral equipment, CRT type peripheral remote equipment". (Id., p. 3351.) GE proposed three 635 processors "with an assortment of drums and disks"; Bunker Ramo "was the vendor responsible for the remote peripheral equipment". (Id., pp. 3351-52.)

Eastern evaluated all three of the proposals. The peripheral equipment involved represented 70 to 75 percent of the total cost of each of the systems and, according to Heinzmann, was an "important factor" in Eastern's ultimate vendor selection. They selected IBM because after going "through all the economic analy[s]es, it turned out that IBM probably had a favorable edge somewhere in the range of five to ten per cent". (Id., pp. 3352-53.)

As noted, when American first implemented SABRE in

1963, processing was performed on two IBM 7090 processors and IBM 1006s.* (Tr. 75862, 75990-91.) One of the 7090s was installed for "redundant" purposes--that is, as back-up to the other processor which actually performed the reservations processing function. (Tr. 76706-07.) American has through time maintained a redundant or back-up configuration. (See, e.g., Tr. 76707-12.)

In the mid-1960s the 7090s were upgraded to 9090s--7090 processors with additional memory (Tr. 75863-64, 76709); IBM marketed the 9090 configuration to American on an "RPQ" basis, meaning "Request for Price Quotation". (Tr. 75863, 76709-10.)

In the 1968 to 1970 period, American added two System/360 Model 65 processors (again, "redundant" (Tr. 76711)) as front-ends to the 9090s to accommodate the increased workload for the reservation application. In addition to the 9090s and Model 65s, beginning in 1968 American added Honeywell 516 computers to its system to control the IBM terminals used for input and output of passenger reservation data; the Honeywell computers replaced IBM 1006s which, prior to 1968, performed that terminal control function. (DX 4109: Welch, Tr. (Telex) 2929-34.)

In 1972 the 9090s were removed from the SABRE system and three Collins 8500 processors with associated disk drives and tape drives were installed as front-end processors to the two 360/65s. O'Neill testified that American added the Collins

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* O'Neill's brief history of equipment used to perform SABRE is at pages 75990-76005 of the trial transcript.

equipment because it decided

> "that the most practical alternative for them was to develop a capability in the Collins 8500 processors to do that processing [data translation, redundancy checking, editing, validation] and to use the IBM [computer] to do that processin [effecting the reservation transaction, disk file handling, tape drive handling].
>
> "The motive involved is that they felt that would be a less expensive alternative than to acquire a bigger processor to do the whole job." (Tr. 75996-97, see Tr. 75994-95.)

Welch similarly described the reasons for American's 1972 addition of the Collins equipment to its computer system:

> "The best alternative appeared to us at that time, which was similar to what several other airlines had done, was to use a System 360, but we were concerned that that itself would solve our capacity problem, and we decided that we would take a part of the communications work done by the System 360 in the reservations environment, take it out of there in order to enhance the capacity of the 65 itself.
>
> "We then evaluated a number of competitors, selected the Collins System, took the communications program out of the reservations system and designed our own with the help of Collins, and got a very significant throughput improvement as a result of making that fairly substantial change." (DX 4109: Welch, Tr. (Telex) 2932.)

Welch added:

> "On the Collins, we made a decision to take some processing out of the larger frame in order to avoid going to a very substantially larger frame and put it into a smaller one, and to my mind, those options are increasing." (Id., p. 3028.)

By contrast, United Airlines used IBM System/370 Model 195s to perform its reservation work. (Tr. 76015-17, 76106.)

In 1974, American began adding Raytheon PTS-100 programmak terminal systems to its computer system. By mid-1978, there were over 500 PTS-100s located at airports and travel agent locations around the country. At airports, the PTS-100s control Raytheon CRT terminals as well as Raytheon and Di/An ticket and boarding pass printers; they are also used to help operate airport flight information monitors. (Tr. 75971, 75975, 76177-78, 76213; DX 14098.) At travel agent locations, the PTS-100s control a variety of peripheral equipment and, in addition, communicate with Wang and DEC PDP 8 and 11 processors installed at the travel agencies. (Tr. 75781, 76180-82.) The PTS-100 is elsewhere used by other customers, in such areas as: insurance (for inquiry, data capture and information gathering and responding in agent offices), banking (for branch office inquiries, wire transactions and credit checking), government (for accounting and payment recording concerning social service programs), securities (for stock market transactions) and other businesses (for order entry and inventory control). (DX 14098.)

In 1975 American moved its passenger reservation processing from dual 360/65s to dual System/370 Model 168s. (Tr. 75991-92, 76716.) Starting in 1975, American added a number of processors at remote locations as well as at its central site in Tulsa. The remote processors included ICOT 275s and 101s and Incoterm SPD 10/20s. Attached to the ICOT processors are IBM terminals; attached to the Incoterm processors are multiplexing units and Centronics printers. (Tr. 75734-35, 75946-47, 75975-76, 75992-93, 76081, 76099, 76184, 76212-13, 76660-61.) As of mid-1978 American had in its computer system between 6,500 and 7,000 terminals, less than 25 percent of which were manufactured by IBM. (Tr. 76570, 76867-68.)

In the years 1976-78, American also added a number of processors at its Tulsa central site, including: two Amdahl 470/V6s (Tr. 75731); 13 Texas Instruments 990s; 5 Computer Communications, Inc. (CCI) CC-80s; and 6 IBM 3705 communications controllers. (Tr. 75731-33, 76211.) The Collins processors have attached disk drives and tape drives manufactured by CDC. The CC-80 processors use CalComp manufactured disk drives for storage. (Tr. 76039-40, 76171, 76325.)

O'Neill described how the various processors function in performing the reservation application, using as an example, a situation in which data are entered through a terminal controlled by a Raytheon PTS-100:

> "When, indeed, there is information to send, when there is information to send from the 4101s to the PTS 100s, the PTS 100s assemble that information, they then, in turn, put that information in a message and respond to a poll from one of the processors at the central site, which could be a CC 80 or a TI 990 or a Collins 8500 or a 3705.
>
> "Before they transmit the information, they will do a character conversion, they will do a cyclical redundancy check digit calculation and then in response to a poll, they will transmit the information to Tulsa.
>
> "What then happens, when the CC 80 or the Collins 8500 or the TI 990, is that the information is received by one of those processors, it is retranslated, the cyclical redundancy check is made, some editing and validation is done to make sure the right number of characters are there, that the right transition codes have been received, it will then take that information and transmit that information to the 370/168 or the 470/V6 or the 360/65, and that processor will then take that information and do some data manipulation on it

depending on what kind of transaction it is and will use the 3340 disk drives or 3420 tape drives to store the information and will respond to a request, depending on what the transaction was." (Tr. 75994-95.)

According to O'Neill, if American "were to perform the same function in the 168 that we do with the Collins 8500 or the TI 990 or the CC 80, the utilization of the [168] computer would be increased somewhere between seven and eleven percent". (Tr. 75995.) Moreover, O'Neill's staff constantly performs a "tuning" process with respect to his reservation application--"such things as examining what processor is responsible for what activity, such as the Collins 8500s and the TI 990s and the CC 80s, if more work can be performed on those processors, then less work need be performed on the 370/168 or the 470/V6s". (Tr. 76758-59.) O'Neill continued:

> "At least on two occasions in the last year we have moved processing from one processor to the other in order to assist us in providing adequate capacity in the SABRE environment." (Tr. 76759.)

The purpose of this "tuning" or "off loading" is [t]o avoid the acquisition of additional hardware by utilizing software modifications or balancing [among processors]". (Tr. 76762.)

d. <u>Implementation of Other Applications on American's EDP System.</u> Several additional applications performed by American, as described by O'Neill, further demonstrate the variety of different types of computer equipment that may be combined to do data processing tasks.

(i) <u>Flight Planning.</u> American performs a flight planning application, using computer equipment to develop a plan for each flight, which includes altitude, speed, check point, alternative landing, weather and fuel information. (Tr. 75867-68.)

Until 1970, American's flight planning operation was performed using IBM 1620 processors. In 1970, the application was moved to Control Data Corporation 3300 processors and associated CDC disk, tape and printer equipment. In 1975, the work was moved again, this time from the CDC equipment to a combination of equipment including an IBM 360/65 processor located in Tulsa, IBM 2314 disk drives and 3420 tape drives attached to the Model 65, the Collins 8500s in Tulsa, the Texas Instruments 990 processors in Tulsa and several hundred Incoterm SPD terminals at remote airport locations and in American's meteorology department. (Tr. 75917, 75928-30, 75868-75.)

Briefly, American performs the flight planning application as follows:

Weather reports from the National Weather Service are received via communications lines by the Texas Instruments 990s. (Tr. 75867-68.)

American's meteorologists "have the ability to update" the weather information in the TI 990s via Incoterm terminals "where they have had reported incidents of weather that may be inconsistent with what the National Weather Service has provided". (Tr. 75869-70.)

Prior to sending the weather data to disk storage on

2314 disk files connected to the 360/65 processor, the TI 990s perform certain processing, including extracting data relevant for the day's flight patterns, validation checking and cyclical control checking and translation of data into transmitable protocols. (Tr. 75875-78.)

After that processing is completed, the TI 990s communicate with the Collins 8500s which act as an "interface" or, in O'Neill's words, a "traffic cop" between the TI and IBM processors. If the 8500 indicates "it [is] okay . . . to ship data", the TI processor sends the weather data to the 360/65 which stores it on 2314 disk storage. (Tr. 75875-76, 75878.)

The 2314 disk drives also store American's flight scheduling information, which comes "through a combination of different inputs." (Tr. 75879.) Some of that scheduling information is captured on magnetic tapes as a part of other American applications performed by 370/168 and/or Amdahl 470/V6 processors. Tapes created on 3420 tape drives are "periodically . . . load[ed] . . . on the 2314's" which are attached to the 360/65. (Tr. 75880.)

With a combination of the weather data and the scheduling data, the 360/65 automatically creates a flight plan two hours before each American flight is scheduled to begin. (Tr. 75881.) When run, the 360/65 transmits the plan through the Collins 8500 to a remote Incoterm terminal, which prints the plan by a dispatcher at the point of the flight's origin. In 90 percent of the cases a flight plan is "calculated" within five seconds. (Tr. 75885-87.)

Other airlines perform flight planning on different types of EDP equipment, supplied by different vendors. For example, O'Neill testified that Eastern Airlines uses Univac 494 processors; Pan Am uses a number of IBM System/360 Model 30 processors located at various airports; United uses a Univac 1108; and TWA uses an IBM System/370 Model 168. Each system also utilizes associated peripheral equipment. (Tr. 75931-41.)

(ii) "PRAS" and "MOUS". American performs two applications using essentially the same equipment, the passenger revenue accounting ("PRAS") and the match-of-use-and-sale ("MOUS") application.

"PRAS". PRAS is the means by which American keeps track of revenue received from the purchase of tickets, keeps track of funds due from or to other airlines for customer trips in which American is only one of the carriers used by the customer, inputs data into American's various accounts receivable applications, and "collects considerable statistics on information related to the people that fly American". (Tr. 76043-47.)

In 1978, entry of PRAS data was performed using approximately 120 terminals connected to 14 Four Phase IV-6 processors in Lake Success, New York. As the data is entered, it is stored on disk drives attached to the Four Phase processors. (Tr. 76048-49.) The Four Phase processors determine whether each entry has a legitimate city code, a legitimate fare basis and whether the ticket was issued by an authorized travel agent. (Tr. 76054-55.)

Periodically, data stored on the disks are accumulated on magnetic tape drives also attached to the Four Phase processors. (Tr. 76049-50.) Those tapes in turn, are physically moved to tape drives attached to Data 100 processors also located in Lake Success. The Data 100s perform additional processing of the data, including "compaction", "expansion" and "formatting" and handle transmission of the data to American's computer equipment in Tulsa. (Tr. 76050-52, 76055-56.)

The Data 100s transmit the data over telecommunications lines to IBM 3705 communications controllers in Tulsa. (Tr. 76050-52.) The 3705s, with their Network Control Program (NCP) software, "are continually keeping track of the status of the equipment that is associated with them. In addition to that, it is directing the traffic to either the 370/168 or the 470/V6." (Tr. 76056-57.)

The 370/168 or Amdahl 470/V6 then computes the accounting entries related to the passenger transactions, repeats the data checking and verification processes performed at Lake Success, and does "[a]ll the file handling associated with the storing and retrieving of information". (Tr. 76057.)

During each night, the results of the accounting processing are sent by the 370/168 or Amdahl 470/V6 to a 3705 which, in turn, transmits the data to the Data 100 processors in Lake Success; the Data 100's then cause the data to be printed by attached printers for use the next morning by accounting personnel in Lake Success. (Tr. 76053-54.)

<u>"MOUS".</u> MOUS is American's acronym for match of use and-sale. The application matches purchased ticket stubs with ticket stubs actually used by customers, which are collected on board the planes, and attempts "to detect potential fraud or potential irregularities" in the purchase and use of tickets. (Tr. 76059-62.)

In the first part of the application, purchased ticket coupon numbers are "read" in Lake Success by a Recognition Equipmer (REI) scanner which O'Neill described to the Court as "very similar to the equipment that you probably saw at Chemical Bank . . . [t]he equipment that was processing the checks". (Tr. 76060.)

The coupon data input by the REI scanner are stored on an attached tape drive. The resulting tape is physically transported to a tape drive attached to a Data 100 processor, at Lake Success, which then transmits the data across telecommunications lines to a 3705 in Tulsa, which in turn "directs it either to the 370/168 or the 470/V6, and we store that information on 3420s, which is tape located in Tulsa". (Tr. 76061-62.)

<u>Equipment Alternatives for "PRAS" and "MOUS".</u> American acquired the Data 100 equipment at Lake Success in 1974. (Tr.

76065.) At the time, IBM proposed System/370 Model 115s to "do the same job the Data 100 is doing" (Tr. 76067-68); that is, "the tape handling, the preliminary processing, the printing, the formatting, the communication handling". (Id.) O'Neill added that "[t]here were some other potential vendors as well" who made competitive proposals. (Id.) Another alternative then considered by American was to centralize the work to be done by the Data 100's by moving that function to the processors located in American's main center in Tulsa. O'Neill testified that American had recently decided "that the accounting function in Lake Success will indeed be closed and that whole function will be transferred to Tulsa". (Tr. 76069.)

The Four Phase equipment used in the PRAS and MOUS applications was acquired in 1977. (Tr. 76065.) Before that time, American used GT&E Logic equipment for the same functions. It moved to the Four Phase equipment because United Airlines, from which American purchased the PRAS software, was already using such equipment "and we decided that that might be the best way to do the job". (Tr. 76065-66.)

Prior to the time it chose the Four Phase equipment, American considered a number of alternatives. IBM proposed System/370 Model 138s. GT&E's Logic subsidiary "did not want to lose the business" and proposed a general purpose computer "much like the Four Phase". O'Neill added, "[b]esides that, we looked at a variety. There were a number of people who were offering small processors with data entry support". And in addition, Electronic Data Services (EDS) "proposed that they do all the data entry work for us on a service bureau basis. They made an attractive offer, and they were another bidder which we gave serious consideration to. But it was decided that we wanted to do it in-house rather than operate on a service bureau basis". (Tr. 76065-67.)

(iii) "Sky Chefs". American performs several applications for its Sky Chefs airline food subsidiary. On one of the 370/168s or 470/V6s in Tulsa, American performs general ledger accounting, accounts payable, payroll and some accounts receivable for the subsidiary. (Tr. 76115-16.) Part of Sky Chefs' accounts receivable processing is performed by IBM System/32s installed by American at Chicago and Dallas/Fort Worth. (Tr. 76116-17.) Precisely the same sort of accounting work done for the Sky Chefs subsidiary on the 370/168, 470/V6 and System/32s--general ledger, accounts payable and receivable--is performed by American for another subsidiary, Americana Hotels, on an IBM System/3. (Tr. 76105-06; see p. 1396 below.)

American decided to acquire the System/32s used for Sky Chefs' accounts receivable and for "food control" work in late 1977. (Tr. 76117-19.) Although at the time O'Neill and his staff "concluded that we had adequate capacity on the IBM 370/168 or the 470/V6 . . . to do that job", that alternative was given "very, very cursory" consideration because "[t]he Sky Chefs folks in the field felt more comfortable with a processor on their premises, and we agreed to install some System/32s to see how that might work". (Tr. 76119-20.)

(iv) Americana Hotel Reservations. American performs a variety of applications for its subsidiary, Americana Hotels. Among them is a room reservation application which is performed in three different ways: by an IBM System/3 in New York for the New York City Americana Hotel; by a service bureau called MICOR; and at American's main data processing center in Tulsa--"within the SABRE system"--for the remainder of the Americana hotel chain. (Tr. 76104-05.) United Airlines performs room reservation processing for its hotel subsidiary, Western International, on an IBM System/370 Model 195. (Tr. 76106.) O'Neill noted that the hotel reservation application "is very similar to what we do in the airline business". (Tr. 76107-08.)

American acquired the System/3, and a backup System/3 in late 1976 and early 1977. (Tr. 76107, 76110, 76112.) Prior to making the acquisition, American considered a number of alternatives for the room reservation application: performing it on the 370/168 or 470/V6 processors in Tulsa; having MICOR do the work on a service bureau basis, as it is doing for the remainder of the Americana chain; obtaining a system proposed by Sigma Data "which was, once again, a miniprocessor based system"; and acquiring hardware and software systems from one of "three or four other vendors that were processing reservations systems at that time".

(Tr. 76112-13.)

(v) Message Switching. American performs a number of message switching applications, each in a different way.

O'Neill described message switching generally as "the ability for a person at one location to construct a message, and that message may be an administrative message or something very similar to a telegram, and direct that message to be delivered to some other person either within the same location or at some other location". (Tr. 76022-23.)

The first type of message switching American performs involves the transmission of messages from American to other airlines through an industry communications organization known as ARINC. This switching is necessary when, for example, a customer books a flight on American to one destination and is continuing to another destination on another airline. In such situations, the original reservation message is transmitted from a remote reservation terminal to, for example, the CC-80 processor in Tulsa, "which in turn directs the traffic to a 470/V6 or a 370/168". (Tr. 75700, 76023-24.) The 470/V6 or 370/168 checks seat availability information pertaining to the other carrier which is stored on American's data files in Tulsa and if the other carrier has an available seat, American's 370/168 or 470/V6 processor creates a "message" of the reservation, then "switches" it via the Collins 8500s to ARINC. ARINC, using Marshall 1000 processors and associated peripherals, then transmits the reservation message to the other carrier involved. (Tr. 76025-27.)

The second form of message switching performed by American is processing which it does on a service bureau basis for Texas International Airlines. For that processing, American uses two of its Texas Instruments 990 processors and associated peripherals, which perform the message switching to ARINC in the same way that American uses its Collins 8500s in the example described above. (Tr. 76027-29.)

American's third form of message switching relates to the movement of messages within American itself. For that processing, American uses ARINC which performs American's internal message switching on a service bureau basis using Collins 8400s. (Tr. 76029, 76031.) O'Neill testified that American instituted the service bureau arrangement with ARINC at a time when a number of other carriers were doing their internal message switching in the same way. However, by 1978, American was "one of the last major carriers who have not developed our own internal message switching capability". (Id.)

Other airlines perform their "message switching" function using different EDP equipment. For example, Eastern Airlines uses Univac 494s (Tr. 76031-32); United Airlines uses Univac 1108s (Tr. 76032); and TWA uses the same 370/168s that it uses to perform reservation and passenger service applications; in the early 1970s, prior to using the 168s, TWA did message switching on ITT 9304 processors. (Tr. 76033.)

79. Union Carbide. John D. McGrew, Director of Operations, Computing and Telecommunications Services at Union Carbide, testified in July 1978 concerning the data processing operations of his company. Mr. McGrew has been involved in data processing since the mid-1960s at the divisional, regional and corporate levels within Union Carbide. Among his professional activities, Mr. McGrew is a member of the Top Computer Executives, was Chairman of a data processing task force established by the Governor of West Virginia, and was in the late 1960's West Virginia's Commissioner of Data Processing Information Systems Services. (DX 3684.)

Union Carbide is one of the twenty-five largest industrial companies in the United States. In 1977, Union Carbide reported revenues of $7 billion. It is a diversified company, engaged in the development and manufacture of chemicals, plastics, gases, metals, carbons and various consumer products. (DX 3685)

a. Union Carbide's Configuration. Union Carbide has a highly centralized computer system. Although the system consists of electronic data processing products located at between 100 and 200 locations across the country (Tr. 77783), most of those locations are remote batch entry stations. The bulk of the system's processing and storage capability is located at two centers: one in Tarrytown, New York, and one in South Charleston, West Virginia.

Union Carbide's system reflects the company's data processing philosophy. As McGrew testified, "centralized control of data processing is important for its efficiency". (Tr. 77782.) He continued:

> "Our approach to having the efficiency of centralization and the responsiveness of decentralization is basically to do our data processing on a wide variety of terminals and devices where we can get at least some of the efficiency of having large data centers but have the information readily available at one hundred, two hundred locations across the country . . . .
>
> "My personal view is we should maintain central control of processing." (Tr. 77782-83.)

The evolution of Union Carbide's computer system in the 1970s is decidedly different from the situations at Chemical Bank and American Airlines; it is virtually the opposite of the situation at the Southern Railway, which is discussed on pp. 1435-37 below. During the 1970s, Chemical and American--to varying degrees--implemented increased distribution of processing function within their systems; they increasingly off-loaded work of large processors to smaller processors and other intelligent devices within their systems; and they increased their use of stand-alone systems to perform functions and/or applications otherwise done or capable of being done on the larger processors. As later described, during the 1970s the Southern Railway established a vast distributed processing network in a successful effort to move away from a centralized data processing approach.

Union Carbide's computer system, on the other hand, changed from a highly decentralized configuration in the mid-1960s to a highly centralized configuration in the mid-1970s.

Prior to 1970, the company operated on a decentralized basis, using approximately 30 separate computer systems at locations around the country for diverse applications. As the result of a 1965 study, however, Union Carbide found that approach to be costly and inadequate to handle needed communications within the system. (Tr. 76392-407; DX 13557, pp. 6-7.) The company decided to centralize its system and, by 1970, it was down from thirty to four data processing centers: Chicago; Tonawanda, New York; South Charleston, West Virginia; and New York City. (Tr. 76412.) At that time, 1970, the company had a "very small communications" function; it was "doing some remote computing over terminals but not very much". (Tr. 76413.)

In the 1970-71 period, largely as the result of an effort to save money in the face of a recession, Union Carbide further consolidated its system, from four main centers down to two: a new facility in Tarrytown, New York and the South Charlesto location. (Tr. 76413-14.) With that consolidation, the size of Union Carbide's communications function increased. McGrew testified that "there was more communications coming along all the time. In order to consolidate these computer centers, it was necessary to add a lot of remote terminals. . . . So the communications element became quite large, much larger." (Tr. 76414.) From "not very much" communications activity in 1970, by 1978 Union Carbide's data processing system simply "could not function" "[w]ithout [its] communications". (Tr. 76413, 77212.)

As the size and importance of Union Carbide's terminal network grew, processing capability was added to manage it. Beginning in the early 1970s, Union Carbide installed intelligent Data 100 remote batch entry devices; in the mid-1970s, it installed Comten 476 processors to handle message switching, and Comten 3670s to serve as communications front-end processors to the system's 370/168 and 165-II central processing units in Tarrytown and South Charleston.

b. Union Carbide's System Configuration: 1978. In mid-1978, the portion of Union Carbide's computer system located at Tarrytown included:

(i) An IBM System/370 Model 168 multi-processor (MP) configuration, leased from Finalco. (Tr. 77327, 77341.) Each of the 168s had one megabyte of IBM-manufactured memory, covered by the Finalco lease. Union Carbide purchased three additional megabytes of National Semiconductor-manufactured memory from Itel. Subsequently, Union Carbide purchased three more megabytes of National Semiconductor-manufactured memory, this time from Memorex. After that purchase, Memorex took over maintenance responsibility for all six megabytes of non-IBM memory in the 168-MP configuration. (Tr. 77339-40.)

(ii) An IBM System/370 Model 165-II central processing unit, which Union Carbide had purchased. The 370/165-II had two megabytes of IBM-manufactured memory. Union Carbide later installed an additional two megabytes of AMS memory. (Tr. 77364

77367, 77414-15, 76509-10.) There were, according to McGrew, two reasons for that procurement. First, "[t]he AMS transistor memory was much cheaper than the IBM . . . core memory on the 370/165 Model II". (Tr. 77382.) Secondly, IBM did not offer more than three megabytes of main memory on the 370/165-II and Union Carbide "felt the machinery would operate more efficiently if the total memory were enlarged past three megabytes". (Tr. 77383.) The addition of the fourth megabyte permitted Union Carbide "to keep the 370/165 longer" than it otherwise would have kept it. (Tr. 77385-86.)

(iii) Thirty-two Storage Technology tape drives and their associated controllers. The STC drives, which offered storage density of 6,250 bits per inch, replaced previously-installed STC drives featuring 1600 bpi density. (Tr. 77298-303.) With respect to Union Carbide's original installation of STC tape drives, McGrew testified:

> "The tape drive history here is that when the Data Center was originally at 270 Park Avenue, which it was before 1970, we started off with IBM drives. Then we converted to Telex tape drives.
>
> "When the move was made from 270 Park Avenue to Tarrytown, and this new Data Center was set up, we started the Data Center up with Storage Technology drives." (Tr. 77309.)

As for Union Carbide's selection of STC, McGrew testified that price was "definitely" a factor (Tr. 77310) and explained:

> "Our analysis indicated to us that they were the best tape drive on the market. They were reliable, they were cost effective.

"At the time we first started dealing with them, they were very hungry for our business. We had and still have a very good vendor relationship with Storage Technology. It would have been, of course, possible to install, I suppose, many other kinds of drives, but they were our best pick, our best alternative." (Tr. 77308.)

Notably, Union Carbide's decision in favor of STC occurred only about one year after STC was formed.

At the time of his testimony, McGrew was considering the acquisition of a mass storage device. He testified that, "[o]n a data basis it would be possible to put all of the data" stored in Tarrytown's 40,000 magnetic tape library "onto a mass storage system". (Tr. 77430-31.) McGrew was familiar with mass storage products offered by IBM and CDC and added that STC representatives had indicated they had a device under development. Union Carbide had not acquired the IBM or CDC devices because they had a "high degree of mechanics" in them, and Union Carbide "would prefer to wait for a device that was completely electronic". (Tr. 77432-33.) McGrew added, "If we find that it is going to be a long wait before a completely electronic device is available, in my judgment we will go ahead with one of the existing types of mass storage". (Tr. 77433.)

(iv) Six IBM 3330 disk drives, thirty-four IBM 3350 disk drives and their associated controllers. At the time McGrew testified, Union Carbide planned to keep its 3330s installed but begin replacing its 3350s with Memorex-manufactured plug-compatible replacements. McGrew explained that Union Carbide had "given Memorex about half of our business because they are cheaper, and . . . we are testing them out now to see how reliable they are". (Tr. 76480.)

(v) Two Comten 476 processors and associated peripherals. The Comten-supplied equipment is used as the message switching center of Union Carbide's system. The processors are "redundant"; that is, one functions as a "back-up" for the other. The associated peripherals include: four "double density" "2314-type" CalComp-manufactured disk drives; three Kennedy-manufactured tape drives (with an integrated control unit (Tr. 77200)); and a line printer. (Tr. 77169-70.)

Prior to installing the Comten 476s, Union Carbide performed its message switching functions using IBM System/360 Model 30 processors. (Tr. 77179.) The Comten equipment was chosen "because of price, quality, and some of the services that they promised to give us". (Tr. 77209.)

(vi) Two Comten 3670 processors. These processors are used "to control the communications to and from the 370/165/168". (Tr. 76479.)

(vii) IBM printers and card reader/punch devices. (Tr. 76500.)

(viii) A Data General Eclipse C/300 processor with 256,000 bytes of main memory, two 3330-type disk drives and controller, a tape drive and controller (integrated within the CPU's frames) two printers and 13 CRT terminals. (Tr. 77313-17.)

The portion of Union Carbide's computer system located in South Charleston, West Virginia, included the following equipment:

(i) An IBM System 370/Model 168 multiprocessor configuration, leased from Finalco. (DX 3700, p. 10.)

(ii) An IBM System/370 Model 165-II central processing unit (purchased) with 1 megabyte of IBM-manufactured memory, 2 megabytes of AMS-manufactured memory and 1 megabyte of CDC-manufactured memory. (_Id._, pp. 5, 10, 16, 21.)

(iii) Thirty-two STC tape drives and associated control units. (_Id._, pp. 22-25.)

(iv) Approximately 22 IBM 3350s, 8 Memorex 3650 disk drives and 8 Memorex 3675 disk drives and associated control units. (_Id._, pp. 14-16; pp. 20-21.)

(v) Seven Comten 3670 processors used, as in Tarrytown, as communications controllers. (_Id._, pp. 33-35; see, Tr. 77470-71.)

(vi) IBM printers and card reader/punch devices. (Tr. 76500.)

Still other portions of Union Carbide's computer system were installed at numerous locations remote from the two central sites. For example, in Tonawanda, New York, there were two GE processors (a 430 and 440), with associated GE peripheral equipment, (DX 3700, p. 133) and a Honeywell 66/17 processor with its own complement of peripherals. (_Id._, p. 93.) Spread throughout the country were: Data 100 remote batch entry devices, Harris 1620 processors and associated peripherals, Four Phase processors and associated peripherals, and a wide assortment of terminals. (Tr. 76500-01.)

c. <u>The Implementation of Union Carbide's Order Entry Tasks.</u> Each of Union Carbide's product divisions performs an order entry function. Each does so, however, in a different way, using some different and some common equipment because "[t]he needs of order entry vary depending on the business and, therefore, the application is done in different ways depending upon the need of the business". (Tr. 76503-04.)* A brief review of each division's approach is illuminating of some of the alternatives that computer users may select to perform this common application:

> <u>Chemical Division</u> uses essentially "dumb" terminal equipment at sales offices, which access the IBM 165/168 processors located in South Charleston via the center's Comten 476 and 3670 equipment located in Tarrytown and South Charleston. (Tr. 77602; see also 77603-06.)
>
> <u>Home and Automotive Products Division</u> similarly uses "dumb" CRT terminal equipment, located at sales offices. That equipment accesses customer files maintained by the 165/168 processors and storage equipment at Tarrytown. (Tr. 76520.) No local data files are stored at this division's sales offices.

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* McGrew provided a general explanation of what "order entry" is: "It is simply a system that begins the process of making a shipment to a customer." (Tr. 77594.)

Linde Division uses Four Phase "intelligent" equipment at its sales offices and Data 100 "intelligent" equipment at its plant sites, which collect and store data locally, perform editing and other processing functions before transmitting data to the Tarrytown 165/168 processors. (Tr. 77590-93.)

Metals Division has only computerized a portion of its order entry tasks. In that portion, the division uses key-punches and cards which are used by Data 100 terminal equipment in Tarrytown, which communicates the data to South Charleston 165/168 processors for "batch run[s]" of the data. (Tr. 77586-90.)

Carbon Products Division uses teletype "dumb" terminals, which communicate with the Comten 476 in Tarrytown. That processor stores data from both sales offices and plant locations. At night the data is physically removed--by transfer of magnetic tape reels--for processing by the IBM 165/168 processors located in Tarrytown. (Tr. 77585-86.)

Battery Products Division uses Burroughs B1728 computer systems located in sales offices and Burroughs TC-500 intelligent" terminals located in its warehouses, which in turn communicate at the end of each day with a Burroughs B1728 at Tarrytown. (Tr. 76505-07.) The data, as edited or otherwise processed during the day, is then transferred physically--again by magnetic tape reels--from the Burroughs equipment to STC tape drives attached to the IBM 165/168 in Tarrytown, for further processing. (Tr. 76507-08.) The output from that processing takes two forms: a listing of invoices, printed in Tarrytown on IBM 3211 printers and the generation of a new tape reel for transmission back to the local sites via the Burroughs equipment. (Tr. 76508-09.)

McGrew testified that this division's order entry could also be performed using "dumb" terminals linked directly to the Tarrytown equipment. (Tr. 77484.)

d. <u>Other Current Applications at Union Carbide.</u> Two additional applications performed by Union Carbide and described by McGrew are of interest.

The first is the company's so-called "rail car" application, which is used to maintain current, accurate information on the whereabouts of its large rail car fleet and hence to permit the company to cut costs and use the fleet more efficiently. (See Tr. 76483-85.)

Each night, the company uses a General Automation SPC 16/45 processor, with attached Wang-manufactured tape drives and CalComp-manufactured "2314-type" disk drives--all maintained by Raytheon Service Corporation (Tr. 76485, 77255, 77262)--to inquire of numerous railroads concerning the location of Union Carbide fleet cars. McGrew explained that "the railroads themselves have systems by which cars are spotted, located". (Tr. 76474.)

The information obtained from the railroads "goes into the General Automation computer," where it is first stored on disk and then dumped onto magnetic tape (Tr. 76477), which, after a conversion, is mounted on an STC tape drive connected to the 168/165 configuration in Tarrytown, and transmitted to the data center in South Charleston, through a Comten 3670 front-end processor which is also located in Tarrytown. McGrew explained the 3670's function:

> "[I]n our system . . . we have many remotes all over the country using our system literally at their beck and command. Whenever they want to use it, we make it available.
>
> "The logic of that is extensive, so we use another computer to control the communications to and from the 370/165/168 and that is a Comten computer processor." (Tr. 76479.)

McGrew explained, "we use the 370/165/168 at South Charleston to reorganize this information, and we put it in a data base mode. It is an IMS data base, an IBM software package, to reorganize this information". (Tr. 76480.) The information is then stored on disk--"it could be [an] IBM disk or it could be [a] Memorex disk. We use them interchangeably". (Id.)

The users of the rail car information are in Union Carbide's Chemicals Distribution Group, which is located approximately ten miles from the South Charleston data processing center. The proximity to that center of the principal rail car data users explains why Union Carbide transmits the data from Tarrytown to South Charleston. As McGrew testified:

> "For communication cost reasons it makes sense to have the information more local so that short distance communication lines can be used rather than long distance communication lines.
>
> "The reason that the General Automation machine is here [Tarrytown] rather than in South [Charleston] . . . is that this is the communications hub of the company . . . and it

was deemed to have it here where the communications technicians could in effect monitor it and watch over it." (Tr. 77257-58.)

The members of the Chemicals Distribution Group have Terminal Communications, Inc. (TCI) CRT terminals which they use "to inquire against this information so that every morning we can look into this data bank and we find out exactly where every car was . . . at 3:00 or 4:00 o'clock this morning on the railroads". (Tr. 76481.)

The second additional application of some interest is the company's accounts payable application. For that application Union Carbide uses, among other equipment, a Data General Eclipse C/300 system, with 256,000 bytes of integrated main memory and associated peripheral equipment. (See pp. 1405-06 above.) That configuration, which is located in Tarrytown, is connected via a telecommunications line to the Comten 3670 front-end processors and the IBM 370/165 and 168 processors at that center. (Tr. 77314.)

Bills reviewed daily are input to the Eclipse C/300 system via its terminal equipment. The accounts payable personnel access the data in the system during the day in an interactive mode. (Tr. 77323.) Then, in the evening, the information is transferred via magnetic tape reels to the 165/168 processors for check writing and additional processing.

Union Carbide began using the Data General system to perform part of the accounts payable application in 1977. Prior to that time, the work done on the Eclipse was performed on the 370/

165-II and 370/168-MP and their associated peripherals. (Tr. 77322.) When done on that equipment, the application was performed in batch mode. But the "[Accounts Payable] department specified that they wanted to have an interactive accounts payable system". (Tr. 77322.)

> "The Development Services Department of the National Applications Group began to work on those specifications. The Accounts Payable Department also said that they would prefer to do the newly specified work on some kind of a small computer instead of using the central--instead of using the equipment that we already had installed that they were then using.
>
> "This was the equipment that was chosen by Development Services." (Tr. 77323.)

e. <u>The Battery Products Division's Request for Proposal: A Case Study of Alternatives to Users.</u> Union Carbide's Battery Products Division (BPD) is itself a large business entity. McGrew testified that the division's annual revenues were in the range of $800 to $900 million. (Tr. 77507.) The division manufactures and markets a range of battery products and has offices in Union Carbide's corporate headquarters in New York and in the data processing center at Tarrytown, and maintains sales offices "scattered across the country". (<u>Id.</u>) The division's headquarters is located in Rocky River, Ohio. (Tr. 77499.)

BPD performs a production scheduling function which, as late as mid-1978, was still done on a manual basis.*

Beginning in 1974, BPD began to investigate the possibility of computerizing its production scheduling function. (Tr. 77551.) Various Union Carbide personnel within BPD and from the

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* McGrew explained BPD's production scheduling at Tr. 77493-94.

data processing area conducted an examination of the problem (Tr. 77551-56), ultimately leading, in August 1977, to the creation of a Request for Proposal (RFP) to automate the application.

A copy of the RFP is Defendant's Exhibit 3695. It was sent to eight vendors: Arista, Software International, Comserv, Martin Marietta, IBM, Burroughs, Honeywell and Univac. (Tr. 77497-98.) All but Arista and Software International submitted proposals for the business. Those two vendors "declined to submit proposals based upon the fact that they felt that they are small companies, they do not have the sufficient resources to handle a proposal of this magnitude". (Tr. 77498.)

(i) Configuration options: the "RFP". McGrew explained that in the RFP, the division specified "the different ways that this proposal might be computerized, that might be acceptable ways to bid". (Tr. 77499.) As stated in the RFP, "the actual computer processing and the data base could reside on the existing IBM 370 computers at Tarrytown or a central computer at Rocky River or on minicomputers at plant locations". (DX 3695, p. 49.) The RFP then offered "a general description of six alternate configurations" that would be acceptable to the company. (*Id.*)

(a) Centralized with a host computer at Tarrytown. Under this approach, the entire data base and all processing would be done on the existing 370/168-MP configuration at Tarrytown. The headquarters in Rocky River and all BPD plants would have CRTs for inquiry and data base update purposes, as well as remote job entry (RJE) equipment, consisting of CRTs and printers, for batch inputs and outputs.

Under this alternative, BPD would not have a central processing unit. "There would have been a minimum of [new] equipment necessary in order to fill a proposal". (Tr. 77509-10; See Tr. 77502-03; DX 3695, p. 49.)

(b) <u>Centralized with a host computer at BPD headquarters.</u> McGrew described this alternative as "very similar to the proposal that would centralize this operation at Tarrytown, except for the fact that currently there is no central processing unit at Rocky River. That means that the Battery Products Division would have to acquire a new central processing unit to install at Rocky River if that were the alternative that were chosen". (Tr. 77506; DX 3695, pp. 49-50.)

(c) <u>Distributed with a host computer at Tarrytown.</u> McGrew described this alternative as follows:

> "[It] would be to install at the various Battery Products Division manufacturing locations as well as their manufacturing headquarters at Rocky River, Ohio, central processors that would be operational at each site that would maintain the local records and information necessary for the day-to-day operation of that particular site with the master records and central files being maintained at the Tarrytown, New York Data Center, and the central processing units at Tarrytown and the central processing units at each manufacturing location and the manufacturing headquarters would be in communication". (Tr. 77510; DX 3695, p. 50.)

This approach would involve CRT terminal equipment for inquiry and data base updates at Rocky River and at each plant and for communication, where necessary, with the existing System/370 processors in Tarrytown.

McGrew explained that under this approach the distributed product files at each plant location would maintain "the product code numbers and the data associated with that product that that particular manufacturing site would produce, so that that would be what we would call a subset of the master file". (Tr. 77514.)

(d) Distributed with a host at Rocky River. According to the RFP, "[t]his alternative is basically the same as the Configuration III (Distributed-Tarrytown) with the exception that there will be a new host computer in Rocky River rather than using the existing IBM 370 in Tarrytown". (DX 3695, p. 50; see Tr. 77512.)

(e) Stand-alone Systems. As described in the RFP, "[t]his alternative would use minicomputers at Rocky River and the plant locations". The data base would be "split between Rocky River and plant minicomputers. There would be batch communications between plant minis and Rocky River mini to keep the respective data bases in synchronization and to transmit input transactions and reports". (DX 3695, p. 51.)

McGrew summarized this alternative by stating, "all of the information necessary to do the production and scheduling operation would then be done at each local site". (Tr. 77518.)

(f) Service bureau host. The RFP described this option as the same as Configuration I (centralized-Tarrytown) or III (distributed-Tarrytown), with the exception that the host computer would be located at an outside service bureau rather than at a Union Carbide location. (DX 3695, p. 51) McGrew explained that there would be remote terminals at each BPD site that would communicate with the service bureau's processor. (Tr. 77511.)

(ii) <u>The competitors' responses.</u> As mentioned above, Union Carbide's RFP was responded to by six different competitors: Burroughs, Comserv, Honeywell, IBM, Martin Marietta Data Systems and Univac. (Tr. 77497-98.) The proposals of each differed from the others and most suppliers offered more than one alternative. What follows is a brief description of each supplier's response.

(a) <u>Burroughs.</u> Burroughs' response is contained in Defendant's Exhibit 3703. That response "recommended that a network be implemented which combines elements of Configurations IV and V [Distributed-Rocky River host and stand-alone systems], as defined in the Request for Proposal". (DX 3703, p. 179.) Burroughs' proposed configuration consisted of: a B1860 computer system located at Rocky River, and other B1860 systems at each of BPD's plant sites. (<u>Id.</u>, pp. 176-81.) Certain production-related files would be maintained at Rocky River, such as forecasting and master scheduling data, however, actual product order files, purchasing records, work in process files, and related day-to-day activity data would reside at each plant location. (<u>Id.</u>, p. 178.) The plants would be linked via communications lines to Rocky River. The Rocky River configuration could, in turn, "act as a terminal" to the 370/168 MP in Tarrytown for situations in which data would be sent to or received from that data center. (Id., p. 262.)

(b) Comserv. Comserv proposed two alternative solutions:

> "1. All systems [that is, portions of the production scheduling function] to be run centralized.
>
> "2. Some systems to be run centralized with all of the plant systems to be run on plant computers." (DX 3704, p. 2.)

Comserv stated, however, that: "To best meet your requirements we recommend Alternative 2, the distributive processing approach." (Id.)

Comserv proposed that, under either alternative, its AMAPS (Advanced Manufacturing, Accounting and Production System) software be used, which it claimed is "the most complete and extensive manufacturing and production software system available today". (Id.)

For the "centralized" approach, Comserv explained:

> "We propose that all nine AMAPS modules be installed on one of your 370/168's. Each plant would have its own files and would be able to select its own parameters and controls. The basic processing would be done separately for each plant." (DX 3704, p. 40.)

Comserv further noted that it did not market the "hardware required for [the installation of AMAPS] in this environment", meaning the additional "centralized" equipment solution. (DX 3704, p. 40.)

For the "decentralized" alternative, Comserv emphasized that AMAPS was available for use not only on IBM System/360 and 370 computers but also on the Hewlett-Packard HP 3000. The HP 3000 version of AMAPS "is written in ANS COBOL and performs the same functions as the IBM version. Moreover, it is an on-line, interactive version of AMAPS". (Id.)

Under the "decentralized" approach Comserv proposed that no additional IBM 370 equipment be installed at the central site in Tarrytown and that HP 3000s, which it would market to Union Carbide, be installed at each BPD plant site, all linked by communications lines to the 370/168 MP in Tarrytown. Certain "central information and control" functions would be performed in Tarrytown, and all plant production scheduling work would be done on the HP 3000s, including bill of material, material control and standard costing applications. (Id., pp. 40-43.) According to Comserv, all of the hardware and software proposed under its distributed processing alternative was "completely compatible with the central 370-168". (Id., p. 35.)

(c) Honeywell. In its response to Union Carbide, a copy of which is Defendant's Exhibit 3705, Honeywell described what it saw as the emergence of distributed data processing as an alternative to the older centralized approach:

> "There was a time when state-of-the-art limitations forced users to place all their computer resources at a distant central site, and then to adjust their business operations to meet the restrictions imposed by such centralization.

> "That's changing today. Users now want to be able to distribute the power of the computer in the ways that best fit their needs, with as much--or as little--centralization as is required. They want distributed systems that will provide better response time, with on-site satellite computers and intelligent terminals to eliminate the delays often involved in "round-trips" to a central system. They want distributed systems that will give local management closer, more direct control over local information processing operations, while still conforming to headquarters requirements and standards . . . distributed systems will improve availability, since a component malfunction may have less impact on system performance . . . distributed systems that will mean reduced communications needs, with far more transactions handled locally, closer to the end user . . . distributed systems that will offer almost unlimited flexibility to match the needs of individual organizational structures." (DX 3705, p. 127.)

Honeywell's response described what in its view were "key elements" which may be present in distributed processing approaches generally.

> First, the "host processor": "the computer which provides supporting services to users and controls satellite processors and terminals--the subsidiary devices in your distributed system. It requires no supervision from other processors". (Id., p. 128.)
>
> Second, the "satellite processor": "[l]inked to the host by communications facilities, [it] controls concurrent operation of both batch and transaction-oriented devices, such as unit record equipment, video terminals, and line printers". (Id.)
>
> Third, terminals: the "ultimate component" which "put[s] the power of the computer more directly in the

hands of the end user". (Id., p. 129.)

Fourth, data base and data management software: "[s]oftware that can handle data input, data storage, and data retrieval with considerable flexibility". (Id.)

Fifth, network communications capability: particularly including a front-end network processor, to control the "system's data communications facilities and perfor[m] such functions as routing, concentration, and line/terminal control. Basically, it serves as the link between each host processor and the network, and in so doing, it frees the host from routine communications burdens." (Id., p. 130.)

Sixth, "standard communications facilities": a "'set of rules' which govern the way information will be transmitted". (Id.)

Seventh, "applications development facilities": which offer "the ability to create and test your application programs on one computer--usually at a central location, for the sake of efficiency and control--and then to run them on other computers at other sites". (Id., p. 131.)

Honeywell's bid then outlined three examples of different, yet all distributed, systems which combine all or some of the "key elements". (Id., p. 128.)

One example was a "hierarchical system", which would include a host processor, terminal controllers and remote terminals. In such a system, "[a]lthough only the terminal device control, input/output handling, and editing functions have been distributed . . . it is a very realistic illustration of a distributed system. A considerable amount of processing has been removed from the host". (*Id.*, p. 133.)

The second example outlined was a "horizontal distributed" system, with two or more processors "cooperating in an 'equal partner' relationship". (*Id.*) Communication links connecting the multiple computing centers allow them "to communicate freely", with each center able to pick up some of another center's workload when necessary. (*Id.*)

The third example was a "hybrid system", including two or more host computers, each controlling "an array of satellite processors, terminal controllers, concentrators, and terminals. (*Id.*, p. 136.)

Honeywell's specific proposal to BPD was to begin with a centralized system at Rocky River and implement, over time, a distributed system. The distributed system would have its host at Rocky River, and satellite processors at each BPD plant in turn controlling clusters of terminal controllers and terminals. (*Id.*, pp. 1-10.)

The host for the initial centralized configuration would be a Honeywell Level 66, Model 66/05 processor. (*Id.*, pp. 1, 7-8.) To permit ultimate implementation of the distributed system, Honeywell proposed installation of its Level 6, Model 6/43 "minicomputers" at the various plant locations. The 6/43s "will provide for the initial remote batch, local data collection, and communication concentration requirements of the plants and offer the future capability of distributed systems technology, including such features as distributed data bases, distributed processing and software compatible subsetting". (Id., p. 1.)

Unlike the Burroughs proposal, Honeywell's did not envision significant interaction between the Level 66 host in Rocky River and the IBM equipment at Tarrytown. (See DX 3705, pp. 8-9.)

(d) IBM. IBM initially proposed the installation of an IBM System/3 system at Rocky River, which would include a Model 15D processor, two 1403 printers, eight 3270 terminals and four 3340 disk drives, and similar configurations, but with less disk storage at each of BPD's plant sites. (DX 3706, pp. 284-85.) As IBM described its approach:

> "We recommend that Rocky River and each plant site have its own stand alone computer. A System/3 Model 15D located at Rocky River will perform all central manufacturing planning functions for the Battery Products Division.
>
> "The Master Production Schedule Planning [MRP] function will be done at Rocky River; plant Material Requirements Planning will be performed on IBM's System/3 Model 15s at the respective plant sites. Forecasting will continue to operate on the Corporate System/370s.
>
> "The MRP data bases will reside in both Rocky River and in

the remote plant computers. Rocky River would be responsible for maintaining all Bills of Material. Each plant, with its own Bill of Material, will be responsible for maintaining Routings and Work Center information. In addition, each plant will be responsible for maintaining inventory and cost information for those items in its data base.

"Each plant will accomplish its own inventory and plant costing functions by collecting the raw data and producing summarized data and local reports on the plant's computer. The summarized cost and inventory data would be batch communicated to Rocky River for consolidation. Rocky River would then produce its required summaries and reports for consolidation and batch communicate this information to the corporate system in Tarrytown. (IBM 370/168)" (Id., p. 67.)

Some months later, after IBM's System/34 was announced (DX 13381, p. 1), IBM changed its proposal, moving from individual, stand-alone System/3s to a distributed network of System/34s which would include 5230 data collection equipment, at the plant sites, linked directly to Union Carbide's System/370 processors at Tarrytown, with no System/3 or other system at Rocky River.

Under this revised proposal, IBM recommended that BPD personnel at Rocky River perform generalized planning functions on the System/370 equipment in Tarrytown, through remote terminal equipment and that "the day-to-day operational functions such as production control . . . costing, and inventory management" of the plant sites be performed on the System/34s. (DX 3707, p. 1.)

(e) Martin Marietta Data Systems. Martin Marietta responded to all six system design configurations contained in

Union Carbide's RFP. It initially proposed its Modular Application Systems (MAS) software which could be used with various hardware configurations. Martin Marietta noted that MAS "is 100% written in ANS4 COBOL. Its modularity makes the use of all currently available Data Base Management Systems extremely easy". (DX 3708, p. 16.)

For each system configuration alternative, Martin Marietta proposed the hardware of particular vendors, in each case to be used with its MAS software:

Option 1 (centralized-Tarrytown)

Union Carbide's existing System/370 hardware at Tarrytown, and at the BPD plant locations: a Harris card reader and printer, IBM 3277 CRTs and Codex multiplexors. (*Id.*, p. 26.)

Option 2 (centralized-Rocky River)

A System/370 Model 138 at Rocky River and the same remote plant configurations described just above. (*Id.*, p. 27.)

Option 3 (distributed-Tarrytown)

Union Carbide's existing 370 equipment at the host site and a Hewlett-Packard 3000 system at each plant. (*Id.*, p. 28.)

Option 4 (distributed-Rocky River)

The same configuration as described for Option 3, except that a 370/138 host would be installed at Rocky

River, in lieu of using 370/168 equipment at Tarrytown. (Id., p. 29.)

Option 5 ("Stand Alone Mini's")

A Hewlett-Packard 3000 system at each BPD location. (Id., p. 30.)

Option 6 (Time-sharing Service)

Martin Marietta's own data service network, using its CPU, to which the BPD remote sites (each with the Harris, IBM, Codex configurations described under Options 1 and 2) would be connected. (Id., p. 31.)

Martin Marietta stressed the cost saving possibilities of using its data service organization. It pointed in its proposa to "a large transportation equipment manufacturer" who removed its System/360 Model 50 in-house system and switched to Martin Marietta services, accessed by in-house Data 100 terminals, "tc supply total data processing services at a fixed, long term price". The customer's monthly EDP costs declined as a result from $75,000 to $26,000. (Id., p. 50.)

Subsequently, Martin Marietta submitted a revised narrower proposal to BPD. (DX 3709, p. 1.) This proposal suggested implementing its MAS software initially in a batch, remote entry mode with processing done by Martin Marietta's own data service organizaion. Its proposal included a suggestion that BPD then move to interactive processing, using other modules of the MAS package and Martin Marietta's processing capability.

The proposal noted:

> "Subsequently to this point BPD still retains all options to migrate that system either from MMDS' Network to its own network in Tarrytown (Option 1) or to distributive minis (variously Options 3, 5, or 7)." (Id., p. 21.)

(f) Univac. Univac proposed three alternative configurations to Union Carbide:

(i) an "individualized" system, with "one small computer at each location";

(ii) a "clustered" system, with "five computers, each servicing the locations in a particular geographical area"; and

(iii) a "centralized" system, with "one large computer servicing all locations via telecommunication terminals". (DX 3710, p. 7)

The "individualized" system would involve the installation of a Univac 90/30 system at BPD headquarters and at each plant site. All locations would be linked by communications lines. Each location would essentially do its own processing. (Id., pp. 95, 97.)

The "clustered" system would utilize a "network (master/slave) concept". A 90/30 system would be installed at Rocky River and at four of the plant sites at the remaining six plant locations, terminal equipment would be installed, "tied to the nearest master location". According to Sperry's proposal, this option "provides the most cost effective configuration while providing an effective Manufacturing/Cost Control System for the Battery Products Division". (Id., p. 95.) It represented a "'happy medium' of lower line costs and better response time than [the centralized system], and less operational cost than [the individualized system]." (Id., p. 124.)

The "centralized" system approach proposed by Univac would use a Univac 1100/12 multiprocessor at Rocky River "for controlling and processing the data for the ten (10) manufacturing facilities". (Id., p. 96.) Each of the ten remote locations would access the 1100/12 through terminals linked to Rocky River via communications lines.

(iii) Union Carbide's selection. Union Carbide's Battery Products Division ultimately selected Univac's "clustered" system proposal from among the responses the company received.

McGrew initially "felt that the Martin Marietta proposal was the better proposal" (Tr. 77558)--principally because the Martin Marietta proposal retained greater centralized control.

McGrew described his objection this way:

> "The communication between the 90/30 at Rocky River, Ohio and the facilities . . . at Tarrytown were extremely limited.
>
> "To give you an idea of that, the entire project was estimated to cost approximately $5 million. The programming to provide the communication between Rocky River and Tarrytown was estimated at $35,000, which is not very much programming.
>
> "I felt that the system did not provide enough central

information to the Battery Products Division and that they could do a better job if it were more . . . if it was a more tightly designed distributed network, which the Martin Marietta system could provide.

"That was basically my objection.

"I felt that the design of the system that was being opted for was shaded too heavily toward the local plants and sites and too little toward the central." (Tr. 77566-67; see also DX 3714.)

80. Southern Railway

a. Introduction. John L. Jones, Vice-President of Management Information Services at the Southern Railway, testified in September 1978. Mr. Jones has extensive experience in the field of data processing, spanning virtually the entire history of the industry. (See Tr. 78688-90; DX 3715.) In 1951, while in the U.S. Air Force, he was an operator of an Air Force Univac I computer and rose to become Assistant Branch Chief at the Univac I installation in the Pentagon. In the late 1950s, he was in charge of technical computing at Chrysler Corporation, and in the early 1960s was Branch Chief and Division Chief of Automation Techniques for the U.S. Air Force Logistics Command. He held that position in a civilian capacity at a management level equivalent to the rank of colonel. Jones joined Southern Railway in 1963 and the following year became its Director of Computer Activities. (Id.)

Among Mr. Jones' other professional activities, from 1960 to 1967, he was Chairman of CODASYL's (Committee on Data Systems Languages) COBOL Committee, which, under his direction, issued COBOL specifications ("COBOL 61") to permit users to write application programs that could be run on any general purpose computer which had a COBOL 61 compiler. (Tr. 78866.) He was also the official representative of the United States of America Standards Institute to International Standards Meetings on programming languages in 1961 and 1963. And he has been an invited lecturer at the Department of Defense Computer Institute, the Air War College, the National Industrial College of Armed Forces, the Atomic Energy Commission, the Defense Communications Agency, the Joint Chiefs of Staff and the Air Force Worldwide Data Automation Conference. (Tr. 78688-90.)

b. Design alternatives available to users generally. In his testimony, Jones gave an extensive discussion of the alternatives that, in his view and experience, users have available to them in choosing how to design their data processing systems. (See, for example, Tr. 79303-34.)

Jones offered definitions of the various types of systems configurations which users can and do select, beginning with the "centralized" approaches, where "the general thrust . . . is that all processing is done in a large central processor, and information is inquired and dispersed via communication lines to terminal equipment that has mechanical or electrical ability to receive and produce information, but no ability to process it". (Tr. 78904.) In a centralized system, when a user inquires from a remote, "dumb" terminal, "since there is no data or no processing locally, that inquiry must proceed via a communication line to the central processor, be processed and then the answer returned to the local device". (Tr. 78905-06.)

That, however, is not the only form of centralized system that a user can design; there are variations. For example, a centralized system--although not as highly centralized--may include, in addition to the central processing unit, "devices that do some minimum amount of processing, processing mostly related to the transmission itself". (Tr. 79780.) A system "starts to become not centralized . . . when the processing capability that is at the remote site can be determined by and programmed by the user and changed by the user as he sees fit and does some function which relieves the central processor of some of the work load that it would have if all the device was doing was the transmission type of processing". (Tr. 79780-81.)

The "distributed approach is quite to the other end of this idea". (Tr. 78904.) Jones explained that "the basic idea of a distributed approach is to in fact distribute the processing physically as appropriate across the organization. . . ." (Id.) "The effect of this . . . is that instead of putting everything into one big central processor you in fact put processors out at many, many places sharing the work load. And in effect what you do is to store and process the local data locally, but coordinate the entire process in such a way that it is one system". (Tr. 78905.)

In addition to centralized and distributed configurations, Jones identified a third option which some companies choose: a "decentralized" approach. (Tr. 79085.) Jones explained that "decentralized impl[ies] some autonomy as opposed to being connected with communications and processing as an integral system". (Id.)*

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* As noted earlier, Mr. McGrew testified that Union Carbide's data processing approach in the mid-1960s was decentralized. (See p. 1400.)

Finally, assuming a user chooses to configure a system consisting of a single, interconnected network of devices, there are, according to Jones, almost an "unlimited" number of combinations in between the centralized and distributed alternatives (Tr. 79288-89; see also Tr. 79085, 79314-15, 79825-26)--what he called "intermediate designs which are not completely centralized and not completely distributed". (Tr. 78911.) Thus, as an example, the system may have, in addition to central site processing capability, various numbers of "regional processors", "regional processors and local processors", or local processors without intermediate regional processors. (Tr. 79314.)

All of the possible combinations, ranging from the highly centralized, to the "intermediate", to the highly distributed, are available to users as alternative system configuration choices. Jones described the computer systems of a number of railroads with which he was familiar, illustrating their varying approaches.

Some have configured centralized systems:

(i) Southern Pacific "has a large centralized installation in San Francisco and connects in a large number, some four hundred terminal devices to that system by communication lines". (Tr. 78912.)

(ii) Louisville & Nashville, "being a member [or] a subsidiary of the Seaboard Coast Line, ties in with the Coast Line's network and there some of the processing is done in Jacksonville on the main Coast Line installation and some is done in Louisville in that installation, so at the instant time, I think they would be predominantly characterized as centralized at this point". (Tr. 78913.)

(iii) Illinois Central Gulf: "That system would be described as a centralized system. The main processors currently are 370/155s, but at the time I visited there about a month ago they were just installing AS6s [manufactured by National Semiconductor]. . . . But all the data comes in via communication line and goes out to dumb terminals, so I would characterize that as centralized." (Tr. 78913-14.)

(iv) Santa Fe "is a centralized [system]. They have their main installation in Topeka." (Tr. 78914.)

(v) The British Railroad "is a centralized system and, in fact, they have largely adopted the philosophy and programs of the Southern Pacific". (Tr. 78915.)

(vi) The French Railroad's "approach is a centralized approach. They have an extremely large Univac installation in Paris." (*Id.*)

(vii) Canadian National and Canadian Pacific Railroads "are predominantly characterized as centralized systems. Again, the Canadian National has fairly much adopted the Southern Pacific programs." (Tr. 78916.)

Some railroads have implemented "intermediate" systems:

(i) Missouri Pacific "has a large installation in St. Louis. However, they also have some computers, PDP machines by Digital Equipment Corporation, in some number, and I believe it is ten of their major switching yards, so they are more of a combination."

". . . . They have some aspects of the centralized, some aspects of the distributed and, therefore, fall in this middle ground or intermediate." (Tr. 78912.)

(ii) Union Pacific "has a central installation in Omaha and has regional computers.

"By 'regional', they are really divisional. Each division of the railroad has a center and then that regional center connects to various yard offices, and so they are an intermediate type of design." (Tr. 78912-13.)

(iii) Conrail (Penn Central): "They have an installation in Philadelphia with regional centers, so I would characterize them as this intermediate class." (Tr. 78913.)

(iv) The German Railroad "is in the midst of a major implementation program which uses local processors, regional processors and central site processors. It is what can only be called a massive system, predominantly all Siemens equipment." (Tr. 78915.)

Jones' own railroad, the Southern Railway, has a distributed system. "We have our main installation in Atlanta. Our central installation is in Atlanta and presently have a number of machines installed out in the field, on the order of . . . forty-some of one type and about ninety of another type, and our philosophy is very much to the distributed approach that I have described." (Tr. 78914.)

c. Evolution of Southern Railway's Computer System. Jones described Southern Railway's data processing installations when he arrived in 1963 and the "major acquisitions of electronic data processing equipment", made during the ensuing 15 years, that "added to or changed" the railroad's configuration into the "one single system" it had in 1978. (Tr. 78969.)*

Jones described what he called a "process of continual transition and change" that, he anticipated, "will continue indefinitely". (Tr. 78964.)

Jones' testimony, which will be discussed at some length below, establishes at least three basic facts about Southern Railway's computer system:

First, from 1963 to 1978 the configuration of the system has changed completely at least three times: from a decentralized configuration of three separate systems, to a single, large centralized system, to a distributed network.

Second, measured in any of a number of ways, the system has grown enormously in size, capacity and capability, between 1963 and 1978. For example:

(i) the number of locations at which EDP equipment was installed as part of the system increased from

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* Jones defined a "major acquisition" as one "clearly identified as a separate acquisition and which involved either a major change or extension of existing configuration". (Tr. 79051.)

"somewhat in excess of twenty" to "well over a hundred";

(ii) the number of installed central processing units increased from 6 to "in excess of one hundred and fifty";

(iii) the number of disk drives increased from none to approximately 60 (16 IBM 3330 Model 11s, 8 IBM 3350s and over 40 Data General disk drives), with a total of nearly 6.5 billion bytes of storage capacity;

(iv) total main memory increased from about 128,000 bytes to approximately 27 million;

(v) the number of programming applications increased from under 50 to approximately 300; and

(vi) the number of application programs increased from 800-900 to about 8,500. (Tr. 78956-58.)

Third, from a system, in 1963, made up almost exclusively of IBM-manufactured products, it has developed into a system comprised of the products of more than 25 different vendors. (Compare DX 3731 with DX 3729.) In 1963, virtually all of the EDP products in Southern Railway's system, with the exception of several analog computers, were of IBM manufacture. (DX 3731.) In 1978, less than one-fifth of the boxes in Southern's system were manufactured by IBM. (See DX 3729.) And Southern is spending substantial sums of money on the EDP equipment of IBM's competitors. For example, in 1972, Southern embarked on a project to install Data General computer equipment. In that year it spent $500,000, and during the period 1978-1980 it will spend an additional $6 million for Data General computer equipment as part of its on-going project, funded and approved by Southern management, to install Data General equipment at additional Southern yards. (Tr. 79995-99, see Tr. 78967-68, 79032-33.) In addition, Jones has submitted a request for an additional $1 million to purchase a Data General M600. (Tr. 79999.) Thus, Southern's spending patterns have changed substantially. While Southern spent $9.8 million on IBM equipment during the eight-year period 1970-77, it will have spent $7 million in the three years that followed on equipment from Data General--a company which was not formed until 1968 and shipped no products at all until 1969. (See PX 5715; p. 1149 above.)

d. Southern Railway's "major" acquisitions. As stated, Jones identified several "major" acquisitions by Southern Railway in the years since 1963, when he joined the company. (See p. 1435 above.)

(i) The 7040/44 Acquisition. In 1963, "there were three separate and distinct computer systems in place, one of which was doing the revenue accounting operations of the railroad, one of which was doing the expenditure accounting operations, and a third of which was doing some processing in a very elementary way to support the railroad operations". (Tr. 78953.) Revenue accounting was performed in Atlanta, Georgia by an IBM 705 Model 2 processor, with two IBM 1401 processors "which were doing the peripheral processing for that machine; that is, the card-to-tape, tape-to-print . . . operations". (Id.) Expenditure accounting was performed in Washington, D. C. by an IBM 1401 processor and six associated tape drives. (Tr. 78954.) "Elementary" support of the railroad's operations was performed in Atlanta by an IBM 7074 processor "and an associated 1401 for the peripheral work". (Id.; see also DX 3731.)

"[W]ithin the first week or two" that Jones was at Southern Railway, he was instructed by the railroad's President to do two things: "first of all get on with the job of supporting operations by the development . . . of a real-time system, and further, to do this in such a way that the end result was . . . a single general information system for the railroad as opposed to what he had right then, which was three segmented systems". (Tr. 78955-56.)

To carry out those instructions, in 1963 Jones selected IBM 7040/44 processors (with 7740 communications controllers, 1301 disk files, and 1050 "dumb" terminals) to replace the 705, 7074 and one of the 1401s. (Tr. 78970, 78980, 79049-50.) When it "became apparent that [the 7040] processor "was not going to be of adequate capacity", Southern installed 7044 processors. Jones testified that the 7044 was a "pure binary machine"--thought by some at the time to typify "scientific" computing--yet the 7044s were installed by Southern Railway "almost totally" for "business data processing": payroll, revenue accounting, accounts receivable. (Tr. 78983-84.)

Jones selected the 7040/44s for three basic reasons. For one thing, the new on-line system would have a heavy communications load and would have to process data "in a very timely way and make it available to various parts of the railroad operation for taking action". (Tr. 78980-81.) Accordingly, Jones believed "it was very important that the hardware and the program support in the form of what we now call the operating system support was available. The 7040-44 family had that capability already and available in terms of its hardware and its software". (Id.) Second, "the 7044 family had in my evaluation the best COBOL compiler that was available at that time". (Tr. 78981-82.) Finally, because Jones was unsure as to the size and growth rate of the new system's workload, he was "very concerned over selecting equipment which on one hand was economical and on the other hand had the ability or capacity to be expanded, should in fact that be required". (Tr. 78983.)

(ii) The System/360 Model 30 Acquisition. In 1964, Southern Railway ordered 3 System/360 Model 30s which, according to a Southern Railway evaluation, had "twice the memory size, six times greater internal speed and twice the printing capacity of the present 1401s being replaced in Atlanta". (DX 3726.) It was anticipated that the effect of replacing the Atlanta 1401s with the Model 30s would be to reduce Southern's monthly rental payments to IBM by $4000; the possibility that the Model 30s would also replace another 1401 in Washington would save an additional $4000 - $5000 per month. (Id.) The memorandum, which was based on information supplied by Jones, observed:

> "Prices of computers have been coming down while the computer capacities are being increased tremendously. If IBM does not bring out new computers at reduced prices, their competitors take the business." (Id.; Tr. 78988.)*

Southern originally leased the 360/30s from IBM "because we anticipated that . . . our estimate of the five-year life of the 7044 system was probably reasonably accurate, and at the end of that term we intended to go out and evaluate all of the machines that were available to determine what the best choice was". (Tr. 79039.) Subsequently, however, Southern entered into a 6-year lease of the Model 30s with Boothe Computer Leasing containing a "very stiff" cancellation penalty. (Tr. 79040.)

(iii) The System/360 Model 65 and 50 Acquisition. In 1969, Southern installed two System/360 Model 65 processors, two Model 50 processors (which were to perform the "teleprocessing" part of the application), seven 2314 disk drives, two 2703 communications controllers and twenty-four 2420 tape drives (Models 5 and 7). (Tr. 78970, 78999; see 79068-70, 79603-05.)

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* In fact, before delivery of the Model 30, and due to competitive pressures, IBM improved its memory performance and reduced extra shift charges. (See pp. 385-90 above.)

Subsequently, a million bytes of Ampex-manufactured memory was added to each of the four processors. (Tr. 79843.) The newly-acquired 360/50 and 65 and the peripheral equipment "replaced the entire 7044 complex", which consisted at that time of three 7044s, two 7740 communications controllers, four 2302 disk devices and 16 to 20 tape drives. (Tr. 78999.)

Prior to deciding on the IBM equipment, Southern "seriously considered and benchmarked" the IBM 360s, Univac 1108, RCA Spectras and Burroughs 6700 family. (Tr. 79353.) Jones added that conversion from the IBM 7040/44 equipment to any of the considered options, including IBM System/360 machines, was estimated at the time to be "about equal in difficulty". An exception was a conversion from the 7044s to the Univac 1108, which he believed would have been "somewhat easier" than any of the others because both machines were "pure binary" computers. (Tr. 79043-44.) Southern also considered--but in "much less detail"--products offered by CDC, Honeywell, NCR and General Electric.* (Tr. 79353.)

All of the IBM equipment except the 2703 communications controllers was purchased "because it was our evaluation that the size of hardware and the expandability of it . . . would handle our requirements we felt for approximately eight years". (Tr.

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* Despite the fact that Southern "had been a large customer of General Electric in other areas", Jones rejected General Electric because he concluded that General Electric was "not a viable competitor" because "there were some serious problems in terms of how they were managing [the Computer Division]." (Tr. 79353-54.)

79041.) The 2703s were leased "because it was my opinion that these units, which were hard-wired units, that is, they were not programmable units--were not the way that this field--that this was going to develop". (Tr. 79041-42.)

(iv) The Burroughs TC-500 Acquisition. In 1970, Southern decided to install Burroughs TC 500 terminals in its system. (Tr. 79044, 79062.) Jones stated that the TC 500

> "was the first programmable terminal, the first terminal that I was aware of that had in it a processor, a general purpose processor with memory and input and output, that could be programmed to perform in some way as the user desired as opposed to being hard wired". (Tr. 79045.)

Prior to acquiring the TC 500s, Southern had 33 IBM 1050 hardwired "dumb" terminals installed "for putting data into the computer for the on-line system". Southern also had 70 to 80 keypunch and key verifier devices used to enter other data via punched cards. (Tr. 79045.) Jones purchased 100 TC 500s "to replace both the IBM 1050s and the keypunch machines, because it was possible on this terminal to program the Burroughs TC 500 so that in one instance it imitated or acted just like a keypunch machine or a key verifier and in the other case it could be programmed to operate from the point of view of the operator just like an IBM 1050". (Id.)

Because the TC 500s used a different internal code from that used by the IBM terminals, Southern "had to face the question of how do you connect those machines to the 360s which were already installed". (Tr. 79048.) There were two options: IBM could make a "rather extensive hardware change" to its 2703 communications controllers at a cost of $25,000 to $28,000, or Southern could replace the 2703s with a Burroughs programmable communications controller, the DC 1800, which "really consisted of a general purpose computer built by a company named Varian". (Tr. 79048.) Southern opted for the Varian alternative. Jones explained:

> "The Varian then was programmed in such a way that it would communicate with the Burroughs TC500s in the language--when I say 'language', I am talking about the controls and codes and so on that the Burroughs machine required, and would translate that to communicate with the 360 into the controls and code that the 360 needed.
>
> "So from the point of view of the 360, it was still talking to a 2703, but the fact was, this was a programmable control unit that it was talking to." (Tr. 79049.)

Jones summarized Southern's installation of the TC 500s and programmable communications controllers this way:

> "I wanted to point out for the Court that this equipment was installed in 1970, and that, to my knowledge at least particularly on Southern Railway Company, was one of the first times that processing began to migrate, I will say, out of the main processor into the peripheral devices. For example, because of the programmable nature of the Burroughs TC 500, there were certain formats and edits which had been made and checks previously in the main processor, which we now took and moved and put in the Burroughs TC 500 itself.
>
> "That made eminent good sense, because now, as the operator was keying to that device, if an error was made of a type of the changes that we had made, the device itself, the processor in the TC 500 itself would stop the operator and indicate the nature of the error immediately, but long before in the prior system the data would have had to go through the central processor, be checked, and then sent back again.
>
> "So I wanted to point out this was the start of the concept of the distributed process in Southern Railway

Company, and in fact in this situation we now had four computers in tandem: there was a computer in the terminal, the Burroughs TC 500, there was a computer in the communications controller, there was a 360/50, and a 360/65, all in tandem, each doing a part of the processing job.

"I want to make that comment so it would be clear to the Court at what time this process of distribution of the processing started in Southern Railway Company." (Tr. 79062-63.)

(v) The Univac DCT 1000 Acquisition. In the early 1970s, Southern wished to provide its railroad yard and sales offices around the southern United States with "an ability to be hooked directly to the information system and acquire directly from it the information which they required in the conduct of their business". (Tr. 79064.)

To provide that capability, Southern leased 85 Univac DCT 1000 "dumb" terminals. The DCT 1000 was chosen, according to Jones,

> "because it was the most economical, in other words, the least expensive unit which had the capability of receiving a quantity of data and holding it and receiving that data at relatively high speed . . . and then holding it while the much slower action of printing that information out on a character printer occurred locally at the device--all the hardwired function." (Tr. 79064.)

One problem Southern encountered was that the DCT 1000 "operated in still a different protocol . . . than either the IBM equipment or the Burroughs equipment". However, ". . . with the Burroughs programmable communications controller in place, the way that problem was resolved was, we merely extended and added to the existing program in the Burroughs communications controller to add this synchronous communications capability and handle the translation of the Univac protocol to the IBM protocol". (Tr. 79065.)

(vi) The System/370 Model 158 Acquisition. In 1974, Southern made another "major acquisition": a System/370 Model 158 and associated 3330 disks and 3420 tapes.* Jones explained that by 1974, it had become

> "evident that as the volume of particularly the on-line system grew but also was providing data in that process which was being used as a by-product for many other functions in the company, and as those applications grew, it became evident that it was indeed going to be necessary to expand the capacity of our at that time 360 network. We had very carefully designed the 360 network we believed in such a way that it was extremely flexible in being expanded and upgraded without major reorganization or revision of our overall processing scheme.
>
> "The 158 was installed, and the first one replaced a 360/50 in terms of the on-line network that was installed.
>
> "The 360/50 was assigned to some other processing, and then at a later time, I believe the next year, a second 158 was installed and in effect, in terms of its role or position in the network, the information system, replaced the other 50, and then at that point, instead of using a Model 50 to handle the teleprocessing part of the application and a 65 to handle the main data file handling, we assigned the 65 to do the work that the 50 had been doing and the 158 to do the work that the 65 had been doing.
>
> "So we by that change greatly upgraded or expanded the capacity of our information system without disruption to the process, I should say." (Tr. 79068-69.)

At the time Jones testified the 370/158s were still installed at Southern's central site in Atlanta. He described

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* In 1975 and 1977, three more 158s and peripherals were acquired, and by 1977 3 million bytes of AMS and IBM memory was on one of the 158s. (Tr. 78971, 79067-70, 79481-83.)

the types of alternatives available to him, should replacement of the 158s become "desirable". Those alternatives fell into three categories:

(a) install a plug-compatible CPU, available from a number of companies, including Amdahl, National Semiconductor, Magnuson, IPL/Cambridge Memories, and CDC. (Tr. 79311, 79338-39);

(b) "install equipment which is of comparable size to the 158s but operates not on a plug compatible basis but would be to take advantage, then, of our programs being in COBOL and translate the COBOL programs similar to the way we did from the 7044s to the 360s and translate them to a new set of machines, and certainly Univac, CDC, Honeywell, Burroughs, as well as some of the larger machines of DEC and possibly the M600 from Data General--I think Hewlett-Packard has a machine that falls within that category--I think there are a number of alternatives that we can look at in that class of alternatives, that is the COBOL to COBOL kind of conversion." (Tr. 79312);

(c) reorganize the system design so as to distribute some portion of the processing done by the 158s with, as noted earlier, "a very large number of possible combinations" including hardware offered by at least 15 or 20 vendors such as: Burroughs, NCR, CDC, Univac, Honeywell, IBM, DEC, Data General, Modcomp, General Automation, Interdata, Four Phase, Wang, and Prime. (Tr. 79305-06, 79313-17.)

(vii) The Four Phase Acquisition. By 1976, Southern's Burroughs TC 500s were "beginning to have some problems". (Tr. 79073.) After six years of heavy use, their mechanical components "were beginning to show definite signs of old age". (Id.) Also, "the electronics of the device being of the [1970]* vintage were not as reliable as was desired". (Id.) Moreover, the DC 1800 communications controllers "occupied such a critical position" in Southern's network--with all communications from remote Burroughs and Univac terminals to the central site coming through them--that it was "absolutely essential that they be reliable". (Tr. 79074.)

Consequently, Jones began to evaluate alternatives to replace the Burroughs terminals and controllers. He noted that, while in 1970 only Burroughs had, to his knowledge, offered programmable terminals, in 1976 there were more alternative products available than he could easily evaluate. (Tr. 79074-75.) While Southern evaluated products offered by Burroughs, IBM, Sycor, Datapoint, "a large number of vendors had equipment". (Tr. 79075.) Ultimately, Southern chose Four Phase:

> "We took a look at several of them. However, the one that best suited the way in which we wanted to design and implement this data capture function, had the equipment which had demonstrated reliability in terms of several hundred installations around the country, had good economics, a good price, as far as we were concerned, was the Four Phase equipment." (Id.)

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* The transcript says "1960" but Jones obviously meant to say 1970, since elsewhere Jones says the TC 500s were "evaluated in 1969" (Tr. 79044) and "installed in 1970". (Tr. 79062, 79074.)

Southern installed approximately 6 Four Phase general purpose systems which included 100 CRT and keyboard devices. (Tr. 79075-77.)

(viii) The Data General Acquisition. The last "major acquisition" discussed by Jones was that of Data General computers and associated peripherals, beginning in 1972 and continuing up to the time he testified.

In late 1972, Southern installed Data General processors and related peripherals to function as a control system at Southern's then recently opened Sheffield Yard, a hump yard.* (Tr. 79077-79.) A yard control system controls all of the various devices and information systems used to govern the movement of railroad cars in the yard and maintain certain information about them.**

A company known as General Railway Signal was the "overall contractor on the control system" at Sheffield and it supplied the Data General computer equipment "as part of their contract". (Tr. 79078-79.) Southern did consider some other hardware than Data General but in the final analysis selected

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* As Jones explained, a "hump yard" moves railroad cars by "rolling them over a hump or a hill and letting gravity take effect" while in a "flat yard" "the switching is done by the locomotive shoving each car or set of cars". (Tr. 79081.)

** Among the devices, there are power switches, car retarders (to control car speed), scales (to weigh cars), radar instruments (to measure speed) and wind speed detectors. (Tr. 79078.)

Data General. (Tr. 79079.)

The Sheffield installation was more successful than anticipated. Southern's management then decided that

> "it was desirable to explore the possibility and in fact do an experimental or a pilot installation to determine whether or not what we had learned at Sheffield in applying these small computers or networks of these small computers -- and there is in fact a network of five computers at Sheffield -- whether that could be applied to those yards which we referred to as flat yards." (Tr. 79080.)

Southern's flat yard at Savannah, Georgia was selected because it "seemed to embody all of the problems that would be encountered at almost any other flat yard on our system". (Tr. 79081.)

Jones and others "developed a plan for implementing a system very similar or at least embodying the concepts of Sheffield Yard in terms of keeping track of the inventories and controlling the flow of work and therefore the flow of the cars in the flat yard, with the emphasis being to minimize the manual activities that would be required by clerical personnel to keep such a system current". (Tr. 79081-82.)

Southern chose Data General equipment for the Savannah pilot project, which began in 1975. DEC and Hewlett-Packard were considered, and "[t]here were other vendors asking [Southern] to consider their equipment". (Tr. 79082.) Jones found no "significant advantage" to DEC or Hewlett-Packard and "no significant disadvantage" to Data General, so he chose to continue to use the Data General equipment. (Tr. 79083.)

After the successful Sheffield and Savannah tests, Southern proceeded to implement a distributed network of computing facilities at yard locations throughout the Southern Railway system. By 1978, computer equipment had been installed and was functioning at at least 21 distributed network locations (Tr. 79141), and there were plans to install equipment at a total of approximately 140 by late 1979. (Tr. 78967; DX 3725-A.) Under Southern's distributed processing plan, different levels of processing capability and different configurations of equipment, would exist at different locations.

(a) At 23 sites (so-called "Full TIPS"* locations), there would be: 2 Data General S/130 Eclipse processors, 4 Data General 10 megabyte disk drives (or 3 20 megabyte drives), a Data General 2 megabyte "fixed head" disk drive, 5 to 12 Data General CRTs and 5 to 12 Xerox Diablo printers. (Tr. 79143-46, 79154-56.)

(b) At 14 sites (so-called "Small TIPS" locations, see pp. 1454-57), there would be: 1 Data General S/130 Eclipse, 2 Data General 10 megabyte disk drives (or 2 20 megabyte drives), and a "smaller number" of Data General CRTs and Xerox printers. (Tr. 79156-59.)

(c) At 45 sites (so-called "Standard Waybilling" locations, see pp. 1456-57), there would be: 1 Data General S/130 Eclipse, 1 Data General 10 megabyte disk and a smaller number of Data General CRTs and Xerox Diablo printers. (Tr. 79162-63.)

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* For a discussion of Southern Railway's "TIPS" applications, see pp. 1453-59 below.

(d) At 59 sites (so-called "MicroNOVA" locations, see pp.1454-57), there would be: 1 Data General MicroNOVA processor, 1 Data General 10 megabyte disk, 1 or 2 Data General CRTs and 1 Xerox Diablo printer. (Tr. 79159-62.) The installed remote equipment communicated with Southern's central site 370/158s in Atlanta via IBM 3705 communications controllers at the central site. When completed, all remote installations would be similarly linked to Atlanta. (Tr. 79163-69.) The 158s supply the local processors with information each yard needs to prepare to receive a train. (Tr. 79397-98.) However, the central computers are "in no way controlling the local processor[s] other than in the sense that it is providing it the information it needs prior to the time the train gets there. But the local processor, the Data General processor, is completely able to stand alone and do the local processing in terms of its capability to do so and the central processor in no way interferes with that process as it is going on locally in the Data General computer program". (Tr. 79398.)

e. <u>The Implementation of Southern's "TIPS" Applications</u>.

(i) <u>Division of work between the central and remote sites</u>. In 1978, Southern Railway's 370/158 processors at the central site were performing "two general categories" of applications. Jones explained:

> "One of the types of processing that is done on the 158s in Atlanta are what we call the batch processing work, and this is the work which is done on a periodic basis. It

would include all the accounting type of work, such as payroll, revenue accounting, accounts receivable, expenditure accounting, a large number of application[s] for the marketing and sales forces, support of the mechanical department in their repair of cars and locomotives and the billing of that, support of the maintenance of way function, support of the transportation function in terms of daily status reports and all the types of things that we categorize as batch processing.

"Then the other major category is what I have described as our online system, which is that system which is oriented towards continuous operation providing immediate processing and support for the operational aspects of our business, that is, the transportation function, the job of running the railroad.

"The processing that is done by the online system consists of maintaining the large central data files which have the information which pertain to the operation of the railroad which is of interest to the functions that are performed at the location in Atlanta.

"Atlanta is the operational center of our railroad and there are certain offices there which perform some of the monitoring, the planning, the evaluating and the refining functions of our day to day as well as our longer term operating functions, and the central processor keeps that data which is pertinent to the overall railroad processing and does that processing for the central function." (Tr. 79309-10.)

In addition to those two categories, the 158s, in connection with the "TIPS" applications, which are described below, take "data [that] is originated and presented to it" from remote locations in the network, extract "any data that it needs for central purposes", and "transmit any of that data which is required at other locations to those other locations". (Tr. 79310.) In performing that function, each 158 "really can be described as nothing more than a switch which brings the data in and . . . transmits on that which is required at another location". (Tr. 79310-11.)

(ii) <u>The "TIPS" applications and the distributed configuration</u>. The major function of the remote network of Data General equipment is what Southern calls the "TIPS" applications: Terminal Information Processing System, the word "terminal" there referring not to an electronic data processing device, but to a railroad terminal location. (Tr. 79143-44.) TIPS is actually a large number of individual on-line applications which, as Jones stated in the passage quoted above, support the "operational aspects" of the railroad's business; the "transportation function, the job of running the railroad". (Tr. 79309-10.)

Southern has chosen a highly distributed computer system configuration to handle the data processing necessary to move its cars, keep an up-to-date inventory of their whereabouts and destinations and prepare various documentation relating to them. Jones described the advantages, in his view, to performing such work on a distributed system, as opposed to a centralized one. For Southern, he rejected the approach of centralizing " a process into one very large, very complex system of hardware and software which was both complex and critical. . . . If it is complex, finding the cause of failure and fixing it may be something that you cannot do quickly". (Tr. 79324.) He continued:

> "So one could wind up in a situation, and indeed the situation I did not want to wind up in is where I had everything in one very large complex set of hardware and software and when it failed, the entire system was not operational and I had to fix it immediately, and because of its complexity, I could not figure out what was wrong." (<u>Id.</u>)

Another aspect of the question was, to Jones, his view that "the old economy of scale argument--which is that the central processor is indeed the most economical way to go, because for only a little more money you can get a lot more processing capability . . . has been turned upside down by the advent of the many new vendors making the smaller machines which give you this alternative of designing the system on a distributed basis". (Tr. 79325.) Jones believes that the "smaller machines" represent a hardware choice "which indeed is more economical from the point of view of the total cost and performing that same function in what, again, in my view, is a more reliable, more effective way, a way which gives you greater redundancy at low cost". (Id.)

Southern's choice of a distributed system design "results in taking processing away from the central site, the central machines, and moving it out to the distributed processors". (Tr. 79989.) According to Jones, that movement of function "will have a direct effect on the size and the growth in size of the central processors". (Id.) He continued:

> "And in fact, in our particular case, where we are using 158s instead of what many other railroads are using of comparable size which are 168s, we very clearly have taken some money that was of potential sales to IBM in terms of a big or a bigger central site machine and instead spent that money buying Data General equipment and putting the processing on that equipment out in the field." (Tr. 79989-90.)

(iii) The implementation of particular TIPS functions at Southern Railway. At the "Full TIPS" locations, the Data General configurations perform a number of discrete TIPS applications or functions. At the "Small TIPS", "Standard Waybilling" and "MicroNOVA" locations, subsets of the "Full TIPS"-site applications are performed. (Tr. 79156-64.) Included among the TIPS applications are the following:

(a) <u>Yard Inventory</u>

"This is a complete and total list of all the cars that are in the rail yard." (Tr. 79184.) The Data General computer equipment is used to perform the yard inventory function, which involves tracking "exactly what cars are in exactly what sequence" in each portion of the yard. (Tr. 79187.)

At Southern's Sheffield Yard, the yard inventory application is performed by three interconnected Data General Nova 1200 processors and associated peripherals, rather than by the Eclipse S/130s. Two other Nova 1200s at Sheffield--identical to the first three--perform a process control application of monitoring, controlling and automatically switching cars. The "only difference" between the processors doing inventory and those doing process control is the software loaded into them. (Tr. 79277-79.)*

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* By comparison, it may be recalled that Union Carbide performs a rail car inventory application to keep track of its transportation fleet. For that application, Union Carbide uses a General Automation SPC 16/45 processor and associated peripherals to collect inventory and location data from various railroads, and 370/165 and 168 processors and their peripherals to organize and store an inventory data base to which remote CRTs inquire for rail car information. (See pp. 1409-12.)

(b) Terminal Inventory

This application keeps track of "hundreds and even in some cases thousands of cars that are not in the yard but . . . were switched in the yard and then were taken out on an industry train or a local train and placed at various tracks at various industries around the area. . . ." (Tr. 79187.)

(c) Waybilling

This is the preparation of a document containing "all of the information regarding how a particular car is to be handled in terms of its routing, its destination, and if further it is a loaded car, there would be information as to the contents of the car, the weight of the lading, who the shipper was" and other information. (Tr. 79160.)

Generally, Data General S/130 Eclipse processors handle waybilling in addition to other TIPS applications. At Southern's "MicroNOVA" locations, Data General MicroNOVA computers perform the same waybilling functions that the S/130s perform elsewhere, but those are the only applications that equipment performs. (Tr. 79159-62.)

For Southern's Inman Yard, waybilling is performed on one of the 370/158 processors in Atlanta. As of 1978, Southern plans to remove the waybilling processing for that yard from the 158 and put it on Data General equipment. (Tr. 79546.)

IBM proposed a centralized approach as a result of the 1972 IBM/Southern Railroad joint study which would have required Southern to install 370/168s at its central site instead of the 158s it has. Southern's view, however, was that "the best approach was to, in effect, off-load that processing out of the central site and put it at the local site on these processors". (Tr. 79085-86.)

(iv) <u>Implementation of TIPS applications at other railroads</u>. Other railroads with which Jones is personally familiar perform all or some of the same TIPS applications performed by Southern on Data General computers by means of different types of data processing configurations and equipment. For example:

(a) <u>Santa Fe</u>

Jones described the use of an IBM System/370 Model 145 at Santa Fe's Argentine Yard:

> ". . . I think it is fair to characterize it to say that they are doing the same function there at the Argentine Yard on the 370/145 as we are doing with the Nova machines, the five Nova machines, at Sheffield Yard." (Tr. 79281.)

Jones also described Santa Fe's use of a Univac 1106 computer for its Corwith yard:

> ". . . at that yard, they are doing these functions [that is, the inventory functions done by 3 Nova 1200's at Sheffield] supported by a UNIVAC 1106, which is in Topeka, and in that instance, then, they have all of the CRTs and printers which are physically in the yard at Corwith Yard near Chicago, connected by communications lines to the

> 1106 in Topeka, and the processing is actually done on that 1106, UNIVAC 1106, in Topeka, and all the information is shuttled back and forth over the communications lines." (Tr. 79281-82.)

(b) Seaboard Coastline

Seaboard is using Modcomp equipment at three yards to perform the same range of functions as Southern is performing with its Data General network. (Tr. 79282-83.)

(c) Illinois Central Gulf

Illinois Central Gulf is using General Automation equipment at their Baton Rouge yard to perform the same functions as Southern's Data General equipment performs. (Tr. 79283.)

(d) Missouri Pacific and Union Pacific

The Missouri Pacific is using DEC equipment at yard offices, and the Union Pacific is using DEC equipment at a combination of regional or divisional offices and larger yards to perform the same TIPS functions as are done by Southern's Data General equipment. (Tr. 79283-84.)

In addition, the Missouri Pacific is "doing the exact same function with their waybilling function that [Southern is] doing". However, Southern uses its Data General equipment and the Missouri Pacific has implemented the application on a central site 370/168 with CRTs and printers at approximately 87 remote locations, linked by communications lines. In both instances, "the function is exactly the same". (Tr. 79285-87.)

(e) Southern Pacific

At the time of Mr. Jones' testimony, the Southern Pacific was "still studying how they want to implement the waybilling function". (Tr. 79288.) Although their "orientation" had traditionally been toward "the single large centralized system", they had "begun to do some things which would indicate that they are beginning to look at some distribution of this process. . . ." (Id.) However, the Southern Pacific had not "yet completely decided whether they would follow the Missouri Pacific style or whether they would follow [Southern's] style or whether they would follow some one of the almost unlimited combinations in between those two styles . . . ." (Tr. 79288-89.)

As for the yard inventory function, the Southern Pacific performs that, for all but the West Colton Yard, on a centralized basis, using two central 370/168s and remote "dumb" IBM 1050 terminals with card punches.* For its West Colton Yard, it decided to "offload" the yard inventory application from the 168 to a separate 370/145 which is located in San Francisco and communicates with terminals at the yard via communications lines. (Tr. 79289-95.)

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* The centralized system at Southern Pacific is called TOPS (Total Operations Processing System) and was "designed by a joint effort of IBM and Southern Pacific". (Tr. 79289.)

81. General Motors

a. Overview of Computing at General Motors. Donald E. Hart, at the time of his testimony in September and October of 1978, had been Head of the Computer Science Department of General Motors Research Laboratories ("GMR") for over 17 years.* The Computer Science Department has been a "leading edge" user of computers throughout its existence, and in the 1960s it was one of the "Inner Six" companies that led the way in the development of modern time sharing. (Wright, Tr. 12905-08; McCarter, Tr. 88415; Hart, Tr. 80293.) Hart belongs to several professional associations, including the Association for Computing Machinery, the Institute of Electrical and Electronic Engineers, SHARE (of which he is a founding member), the Society of Automotive Engineers and the American Federation of Information Processing Societies. Hart has also authored more than 40 speeches and publications on computers or computer related topics. (Tr. 80122-28; DX 3752.)

As we have said above (p. 50), upon joining General Motors, Hart participated in the development of the corporation's first computer, SAMJAC, which stood for "Slow as Mollasses in January

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* The Computer Science Department at General Motors Research Laboratories was known as the Computer Technology Department from May 1961 to October 1971 and prior to that time was called the Data Processing Group in the Special Problems Department. (Tr. 80152.) As a matter of convenience, the term "Computer Science Department" was used to describe both that organization and its predecessors during the witness's testimony. (Tr. 80152-53.) Unless otherwise indicated, all citations to the transcript in this section refer to Hart's testimony.

Automatic Computer". (Tr. 80158-59.) That computer was developed as an in-house project because "for the amount of money that Research Laboratories was prepared to budget at that point there was no equipment that was available that we could go out and procure in the marketplace". (Tr. 80159-60.)

Sometime later, GMR went to the outside and acquired an IBM 701. (Tr. 80203-06; DX 3753; Tr. 80186.) In 1956 GMR acquired an IBM 704 (Tr. 80207; DX 3753 (Tr. 80186)), and in 1962 it acquired an IBM 7090, which was later upgraded to a 7094. (DX 3753 (Tr. 80186).) In 1965 GMR installed a General Electric 225, which was upgraded a number of times and eventually transferred to another part of General Motors in 1976. (Tr. 80209, 80322-23.) In addition GMR installed a 360/50 in 1966, a 360/67 in 1966, a 360/65 in 1968, a CDC STAR 1-B in 1971, a 370/165 in 1971, another 360/67 in 1972, and several 370/168s in the 1970s. (Tr. 80297-98, 80304-05, 80318-19, 80321, 80599; DX 3753 (Tr. 80186-87).) Each of those computers was used primarily for scientific and engineering applications, although each was also used for a variety of commercial applications. (Tr. 80206-07, 80353-66.)*

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* Each fell within Hart's definition of a "general purpose electronic digital computer system" which he described as "essentially a problem-solving system which consists of a collection of computer hardware and related software which is capable of solving a variety of problems" and "which executes a stored program". (Tr. 80200, 80203, 80210.) Hart testified further that his understanding of that term had not changed over time and that it represents "the understanding of those people who are practitioners in this field". (Tr. 80201.) Hart also testified that a computer "system" includes "terminals and remote job entry stations, other satellite computer systems, and so on" which are not necessarily located in the computer room. (Tr. 80329-30.)

b. Development of Computer Aided Design for Automobiles at GMR. In 1957 GMR began to investigate the possibility of using computers to assist in the process of designing automobiles. After preparing a feasibility demonstration in late 1958 or early 1959 (Tr. 80228-30), GMR entered into a joint development agreement with IBM to develop a graphics terminal which could be used in the design of automobiles--a process that "at that point took nominally three years". (Tr. 80239-40.) The agreement provided that GMR would develop the specifications and the software while IBM was to develop the hardware. (Tr. 80240, 80252.) In developing this software, which was run on an IBM 7090, GMR designed its own multiprogramming capability that enabled the design programs and the programs of other users to reside in memory at the same time. (Tr. 80250-51, 80257-58.)

This system became operational in 1963 and was called the DAC-1, where "DAC" stood for "Design Augmented by Computers". (Tr. 80256, 80260.) The DAC project demonstrated that it was possible to use computers to achieve a reduction in the man hours required to design a car, but GMR realized that "we could only make a small dent on that total process with one design console". (Tr. 80261-62.) So the next step was "to design a follow-on system with multiple graphics consoles so they could be used by many draftsmen or designers simultaneously". (Id.) The follow-on system was called CADANCE, which stood for Computerized Design and Numerical Control Effort (Tr. 80266-67), and GMR entered into another joint study agreement with IBM for two reasons: first, to make the DAC system more maintainable, and second, "to explore what kind of computer system would be required" and "to determine what kind of graphic consoles they ought to be". (Tr. 80262-63.)

In the course of the joint study IBM disclosed to GMR some of its plans with respect to what became System/360. Hart testified that GMR needed this kind of information because it could not design its CADANCE programming system "without having in mind a particular computer configuration and software support configuration for the target computer that we planned to use". (Tr. 80267.)

GMR's reaction to the System/360 as announced in April 1964 was that it did not have the kind of advanced time sharing capability that GMR felt it needed to support the multiple graphics console of the CADANCE system. Hart testified that the general state of the art with respect to time sharing at the time was not sufficiently developed to support GMR's needs (Tr. 80465-70) and that GMR "vigorously provided" input to IBM and other companies on what its needs were. (Tr. 80278.) Ultimately, GMR sent out a request for proposal to IBM, GE, Univac, CDC and Burroughs for a system that would meet its needs. (Tr. 80282-83.) IBM and GE were the only firms that came back with proposals that GMR believed were responsive (Tr. 80284-86), and GMR ultimately ordered what became the 360/67 from IBM.*

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* GMR's experience with the TSS software that was developed for the 360/67 is described in the section relating to the 1960s and will not be repeated here. (See pp. 424-36 above.)

Initially, GMR put its CADANCE application on an 360/50 and later moved it to the 360/67 when it was delivered in late 1966. (Tr. 80297-98.) GMR and IBM jointly developed an operating system for the CADANCE application called "Interim Timesharing System" or "ITSS". (Tr. 80297.)

c. The Competition Between IBM and CDC at GMR for Its Automobile Design Application. By the late 1960s GMR concluded that ITSS was not adequate to support a sufficient number of graphics consoles and decided to develop its own operating system, which it called the Multi Console Timesharing System or MCTS. (Tr. 80301-02.) At first, GMR planned to build MCTS for the 360/67, but CDC then "approached us and revealed to us that they were developing a computer called STAR, and that that STAR computer would have considerably more power than the 360 Model 67, and that it incorporated time sharing hardware which would allow us to implement our virtual memory time sharing system". (Tr. 80302-03.)*

After comparing the proposed STAR 100 with IBM's 360/67, GMR chose the STAR 100 (Tr. 80301-04) and installed an interim computer, the STAR 1B, for use in program development. (Tr. 80304-05.) Some of the initial program development for the STAR was done on the 360/67 with a compiler that was modified to produce machine code for the STAR 100 "so we could compile programs on the 360/67

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* At the time GMR had those discussions with CDC, only "[h]alf the design [of the STAR] had been completed". (Tr. 80308.)

which were then substitutable on the STAR". (Tr. 80313-14.) Among the applications planned for the STAR, in addition to CADANCE, were analysis of the physical phenomena relating to General Motors' products, FORTRAN applications and commercial applications using the vector processing capabilities of the machine. (Tr. 80310-13.)

Approximately six to nine months after GMR had entered into the agreement with CDC for the STAR, CDC began to experience problems in the development and eventually it became clear that the delivery would be delayed by a year to a year and a half. (Tr. 80306-07.) GMR then "looked more and more deeply into the kind of problems that they were incurring in producing that hardware, concluded that they had made some fundamental design errors; in particular, we discovered much later than we should have that they had not done any simulation studies to verify the logic of their design, and they were running into difficulties operating the high speed hardware in a time sharing environment". (Tr. 80307.)*

In late June or early July of 1972 GMR decided not to go forward with the STAR project, and in September of that year GMR formally terminated its agreement with CDC for the STAR 100 and returned the STAR 1B, which it had leased. (Tr. 80307, 80309; see PX 5766.) At about the same time, GMR installed a second 360/67 and

* The first STAR was scheduled for delivery to Lawrence Livermore Laboratories in California. It was delayed beyond the year to year-and-a-half delay that existed at the time GMR terminated its agreement with CDC. When it was eventually delivered, the STAR's performance for scalar calculations, which had been part of GMR's "basic plans", was degraded. (Tr. 80314-16.)

began running TSS on the system in a duplexed configuration. (Tr. 80318.)

In August 1972, IBM announced the 370/168 and GMR performed a study comparing the 370/168, the STAR 65 and the STAR 100. The results of that study are summarized in PX 5766, a memorandum to Hart from Dr. George Dodd, Assistant Head of the Computer Science Department:

> "The preliminary results of the study . . . indicate that the IBM 370/168 running TSS is the most cost effective alternative.
>
> "Why is STAR less cost effective than the 370/168? A study into this situation yielded an analysis of cost of the major components in each computer system . . . . Although the STAR has a slightly less expensive central computer, the memory, drums and disks account for more than 40% of the cost of the STAR for which STAR prices are 2-3 times higher than IBM prices. The high cost of STAR peripheral devices is the major factor contributing to the higher STAR prices.
>
> ". . . Unless significant changes occur, it is apparent that the IBM 370/168 is a better computer for the CADANCE system. In view of these results the July 5, 1972 decision by GMR management that the CDC STAR-100 contract should be terminated continues to appear valid. The announcement and performance of the IBM 370/168 is such that I now recommend that we substitute this equipment with TSS for design console support." (PX 5766, p. 2; see Tr. 80621-24; see also PX 5748.)

In the fall of 1973, General Motors replaced the two Model 67s with an IBM System 370/168, which ran TSS.* (Tr. 80321.) GMR also acquired an IBM 370/165 in 1971, which was upgraded to a 370/168 in 1974. (Id.)

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* At the time Hart testified, GMR still used the IBM TSS operating system in conjunction with the CADANCE application. (Tr. 80321-22.)

d. Organization and Purpose of GMR's Computer Science Department at the Time of Hart's Testimony. At the time of Hart's testimony, the Computer Science Department was one of a number of professional technical departments within the General Motors Research Laboratories. It employed 90 persons, all of whom worked under Hart, and served two purposes: to conduct research and development "in the art or science of computing" and to "operate a large-scale engineering and scientific computing service which serves the needs of the Research Laboratories . . . and also other staffs and divisions within the General Motors Corporation". (Tr. 80154-56.)

e. Computer Applications Performed at GMR's Computer Science Department at the Time of Hart's Testimony. Hart divided the applications performed at the Computer Science Department into three classes: "engineering", "scientific" and "other" (DX 3769A):

(i) "Engineering" is primarily product engineering, including the design of necessary tools to make the ultimate product as well as the design of the ultimate product itself. Computer aided design, as implemented, for example, by General Motors' own CADANCE system, is included in this "engineering" class, as is structural analysis, which uses the program NASTRAN* to determine the structural strength of sheet metal components, the non-graphic design of automobile components and

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* NASTRAN was originally developed by NASA for use on Control Data Model 6600 or 7600 equipment, converted for use on IBM equipment, and is leased by GMR from a software house named MacNeal Schwendler. (Tr. 80356, 81942-43.)

the control and testing of the engineering process and testing. (Tr. 80353-56; DX 3769A.)

(ii) "Scientific" involves engineering, physics, mathematics (including the application of mathematics to business problems), traffic design, societal analysis and various projects in research and development, including a project in "machine perception" which involves the use of television cameras to provide visual input to the computer and the use of computers to control robots. (Tr. 80357-63; DX 3769A.)

(iii) "Other" includes miscellaneous applications that do not fall into the other two classes, such as marketing, accounting, personnel, payroll and warranty claims validation. (Tr. 80363-66; DX 3769A.)

f. Computer Equipment Installed at GMR's Computer Science Department at the Time of Hart's Testimony. At the time of Hart's testimony, the Computer Science Department had installed two IBM 370/168 attached processor systems and a single 370/168, as well as Memorex 3675 disk drives, IBM 3420 tape drives, IBM 3350 disk drives, Comten 3650 and Memorex 1270 communication controllers, Bell and non-Bell modems, four megabytes of additional memory manufactured by AMS and leased from CDC, IBM and DEC graphics consoles, IBM 1403 printers, T-bar switching devices, DEC PDP 11/34 and 11/40 CPUs that controlled the DEC graphics consoles, an FR 80 CRT plotter manufactured by Information International, and other and "various kinds of terminal devices which are used by the users of this equipment on an interactive basis for solving problems". (Tr. 80332, 80400-15; DX 3768.)

Hart testified that GMR rents the single IBM 370/168 processor from IBM on a month-by-month basis, and both 370/168 attached processor systems are rented from leasing companies on one-year leases. (Tr. 80343-44.) Hart also testified that he intended to replace all of the Computer Science Department's 370/168s with four IBM 3033s beginning in the end of 1978. (Tr. 81900.) He stated that he planned to acquire the 3033s from third-party leasing companies, and that he had requested proposals from vendors on leases ranging from one to three years. He added that General Motors already had a specific proposal for a short-term lease from a subsidiary of the General Motors Corporation. (Tr. 80344-45.)

g. GMR's Computer Procurement Procedure. General Motors Corporation maintains a general procedure for the procurement of equipment. The local unit which wants equipment prepares a request, including a description of the equipment, a proposed method of financing, the total cost, and the expected benefit of acquiring the equipment. If the equipment cost is less than $100,000, either on a purchase or three-year lease basis, approval for acquisition of the equipment can come from local management. If that cost exceeds $100,000, additional corporate approval is required. (Tr. 80345-46.

For the Computer Science Department, requests for equipment with a cost of less than $100,000 are reviewed by the Vice President in charge of General Motors Research Laboratories.

Requests for equipment with a cost exceeding $100,000 are reviewed by the General Motors Information Systems and Communication Activity, and if that equipment is to be used for engineering purposes, it is also reviewed by the General Motors Engineering Computer Coordination Activity. (Tr. 80346-47.)

Hart, as Head of the Computer Science Department, is responsible for deciding whether to request procurement of computer equipment for the Department. Hart's decisions are based on recommendations from his staff, which has the responsibility of assessing the expected demand on the Department by users as well as the responsibility of evaluating the alternatives for satisfying that demand. Approximately ten people within the Department fulfill those responsibilities on a full-time basis, and between 45 and 50 people within the Department make such assessments and evaluations at least part-time. (Tr. 80347-50.)

Hart testified about the purpose of those evaluations:

> "[O]ur objective is to provide the kinds of capabilities that our users require in order to solve their problems. It is to provide sufficient capacity so that they can get their problems solved with reasonable response time or turn-around time. And it is also assuring that we are providing to our users cost-effective tools for the solution of their problems." (Tr. 80350.)

Hart defined the term "cost-effective" as "providing the maximum capability at the minimum cost." (Tr. 80351.) Hart also testified that he considered reliability an important factor in determining the cost-effectiveness of a system. (Tr. 80368-69.)

h. Cost Effectiveness of Computing Alternatives Selected by GMR's Computer Science Department. Hart testified that he believes the Computer Science Department offers a service to users within the corporation that is a "cost-effective computing service through the current time". (Tr. 80370.) When asked the basis for that opinion, Hart stated:

> "Well, maybe the most telling basis is the fact that our computing service activity is set up as a separate accounting center in which all of the costs associated with running a computer -- it includes the computer rent itself or whatever, the renting of the space, the cost of the utilities, the salaries of the people who operate it and maintain the software for it are included within that accounting center. We established rates for the charge for our services that are designed to recover totally the cost of that operation. We have in fact done that. We have each year recovered the cost of operating that computer system.
>
> "This means that the users have had to judge whether or not they are spending their money wisely, and during the period when we have been doing that, the use of our computer activities has increased at the rate of about 40 percent a year." (Tr. 80370-71.)

Users have been charged for General Motors Computer Science Department computers "[s]ince about 1960". (Tr. 80371.) As of the time Hart testified, those users were all groups within the General Motors Corporation (id.) who were "free to go elsewhere outside the Computer Science Department to obtain that computer service" (Tr. 80371-72) and who were not required by General Motors' management "in any sense to obtain the computer service that they are getting" from the Computer Science Department. (Tr. 80372.) General Motors' users have "in fact gone away from the Computer Science Department from time to time", but the overall utilization of the Computer

Science Department's computer equipment "has increased at the rate of about 40 percent a year". (Tr. 80371-72.)

In addition to the willingness of GM users to pay the full cost of operating the Computer Science Department's computers, and his ability to employ "some very high quality people most of whom participated in the process of evaluating alternatives and making selections" (Tr. 80374), Hart identified an important other way in which the cost-effectiveness of the computing service offered by his Department is assessed:

> "[O]ne is to get feedback from our user community as to whether or not they believe that we are operating a good computing service at a reasonable price, and there are clearly two aspects of the cost effectiveness.
>
> "There is the effectiveness question and there is the cost question. And in order to assist us in this interaction with the user community, so-called technical advisory committees have been established for each of the computers running under the two operating systems, MVS and TSS, which include representatives from our major customer environments.
>
> "This group is chaired by an individual outside the Computer Science Department. The meetings are held every one or two months for the purpose of reviewing the services we are providing, to discuss possible new offerings, to discuss new user requirements, to discuss the methods for changing from one kind of equipment to another, and so that provides us with a very effective feedback from the users which helps us to determine and provide the kinds of services which they want." (Tr. 80372-73.)

i. <u>Computing Alternatives Evaluated by the Computer Science Department.</u> Hart testified about the various alternative means of providing computer service which have been evaluated by persons within the Computer Science Department:

(i) One set of alternatives evaluated is the method "by which you obtain the computing horsepower required to carry out the calculations". The alternative sources for computing power include central processing unit vendors, leasing companies, other GM computers and service bureaus, and it can be leased or purchased, new or used. (Tr. 80376-78; DX 3770A.)

(ii) The alternative sources for peripherals include the CPU vendor, leasing companies, PCMs, elsewhere in GM and service bureaus. Another possibility considered by Hart is having the peripherals specially built, either within the corporation or contracted out to an outside company. (Tr. 80378-79; DX 3770A.) Again, peripherals can be obtained under various financial alternatives. (Tr. 80378.)

(iii) Another set of alternatives discussed by Hart involves software, which "comes in multiple flavors", including operating systems, programming languages and compilers, data base management systems, access methods, utilities, general purpose tools and general purpose application packages. These different "flavors" of software can be acquired from a variety of sources, including the CPU vendor, software houses, university groups and user groups. Hart added that "[i]t is possible to build your own." (Tr. 80379-82.; DX 3770A.)

(iv) Hart testified that "[a]n alternative that has to be considered relative to this combination of computing hardware and software is . . . the mode of operation". Possible modes of operation include batch processing, interactive processing, data base management systems. Alternative programming languages have also been available, including FORTRAN, PL/I, COBOL, BASIC and APL. (Tr. 80385-87; DX 3770A.)

(v) Hart testified that there are also alternate sources of terminal equipment including local terminals, remote job entry stations--which can include a card reader and a printer and operate over a dedicated wire or over dial-up telephone circuits--teletypes, CRTs, graphic terminals. Hart testified that these devices are available from the CPU vendor and "many others as well". (Tr. 80387-89.) He also testified that terminals can be either "dumb or smart":

> "The difference is whether the control unit as a part of that terminal has some hardware logic or whether it includes a small general purpose digital computer as the control unit, [f]or if they include the small general purpose digital computer, then some of the work can be offloaded from the large central computer out into the terminal so it can do more of the work to serve the needs of the user, and will require less movement of data back and forth between the terminal and the CPU." (Tr. 80389-90.)

(vi) Finally, in describing the great variety of alternatives available today, Hart contrasted that situation to the state of affairs that existed in the days of the 701 when:

-- "about the only source of the computing power was the CPU vendor itself" (Tr. 80382);

-- "there were really two vendors that I am aware of, IBM with the 701 and Remington Rand with the UNIVAC" (Tr. 80383);

-- "there were fewer [peripheral] options available from the CPU vendors and there were fewer alternate sources beyond the CPU vendor" (Tr. 80384);

-- "there wasn't much software at all" (_id._);

-- "[t]here were no operating systems" (id.);

-- "there were no access methods" (id.);

-- "[t]here were no data base management systems" (id.); and

-- "[a]lmost nothing [was] available in the way of [software for use as] general purpose tools or general purpose applications". (Tr. 80385.)

Commencing with IBM's first commercially available computer, the 701, General Motors' Computer Science Department, as previously described, has used a substantial quantity of successive models of IBM computer equipment and was planning, at the time of Hart's testimony, to install four of the newest and largest central processing units manufactured by IBM, the System/370 Model 3033. Asked for his "business judgment concerning the performance of the IBM general purpose electronic digital computer systems which have been installed in the General Motors Research Laboratories over the period of time that . . . [he] worked there", Hart testified:

> "Overall we have been highly satisfied with the hardware, software, and maintenance services which have been supplied to us by IBM. In fact, I think I sort of commented earlier in my testimony that if we had not been satisfied with the quality of service and equipment, software and services, that we would have been seeking those from somebody else. In fact, in one instance, as I pointed out, we did go off and search for, and attempt to, move to alternative equipment supplied by Control Data.
>
> "As I indicated, our end-goal is to provide a cost effective computing service to our users and we believe we have been successful in doing that with the IBM equipment which we have installed." (Tr. 81962-63.)

j. Hart's View of the Performance of the Computer Industry--Past, Present and Future. Hart, whose experience in the field of computers has been discussed, described his perspective of the history and future of the EDP industry in a paper he prepared for presentation to the annual meeting of the General Motors Committee on Engineering Computations in 1971. According to Hart, the "focus" of this meeting, attended by about 300 or 350 people, "was how computers could be used to reduce cost or to increase the effectiveness with which General Motors could solve its problems." (Tr. 80176-77.)

Hart began his 1971 presentation as follows:

> "20 years ago, GM didn't have any computers--now there are nearly 500 computers in GM--for which the annual rental is about $100 million." (DX 3753 (Tr. 80186).)

He continued by describing the "revolutionary changes" in computing which had occurred at General Motors Research Laboratories:

> "The changes which occurred in the 14 years between the 701 in 1954 and the 360/65 in 1968 can only be described as revolutionary. I'd like to highlight a few of the changes that have taken place.
>
> "The first revolution was the 701 itself--it was 100 times as fast as the CPC [the IBM Card Programmed Calculator] and only cost 10 times as much--therefore problem solving cost was decreased by a factor of 10.
>
> ". . . .
>
> "For $20,000 [the monthly rental price of the IBM 701] you can now purchase a whole minicomputer[*] which could run

* "The minicomputer in my mind, or particularly at that point, represented a small computer which again was a general purpose digital computer system, so 'mini' referred to the size of the machine and there were a class of these smaller machines referred to by this term 'minicomputer.'" (Tr. 80212.)

rings around the 701. It is interesting to note, during the past 20 years, starting with CPC, while computing cost has gone down by a factor of 1000, cost of engineers and scientists has tripled.

"These improvements from 701 to 360 have largely come about from revolutionary changes in computer hardware technology.

". . . .

"There has also been a revolution in software technology which has helped to make more efficient use of computers [hardware*]--this is the operating system (currently typified by IBM's OS/360)." (DX 3753 (Tr. 80187-88).)

Hart attributed an increase in manpower productivity to "the revolution in programming languages", including FORTRAN and PL/1 (DX 3753 (Tr. 80189)), which were developed by IBM. (Tr. 80214-15, 80217-18.) Hart stated that "the latest revolution is interactive computing--which is often loosely referred to as time sharing. Time-sharing is what makes it possible for many users to share the computer's resources at the same time". (DX 3753 (Tr. 80189).)

"From our own experience and discussions with others who have solved problems both ways, interactive and batch, we conclude that problem solving time is reduced by from 3/1 to as much as 10/1, with a good average being 5/1. Since people don't usually make very good use of their wait time in a batch mode, the increase in engineer's productivity is nearly that large. And there does not appear to be any significant increase in computer cost--for <u>solving the same problem</u>.

". . . .

"If it sounds like I am promoting interactive computing, it's because I am. I believe it represents a revolutionary new

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* This and subsequent bracketed insertions of text in the speech represent handwritten notations made by Hart prior to presenting the paper. (Tr. 80179-86.)

way of using computers to solve problems, and we are only beginning to understand what it means." (DX 3753 (Tr. 80189-91).)

Those "revolutionary changes"--the 701, the System/360's computer hardware technology, the software technology in operating systems typified by IBM's OS/360, high level programming languages and interactive computing--were not easy to make. As Hart stated in his 1971 speech:

> "I've been telling you how wonderful these revolutions have been, but they also cause problems. Revolution means change, and change costs time and money--in the form of retraining and program conversion.
>
> "Consider the engineer who was happily getting his answers printed out on the CPC at 100 LPM.[*] Then we traded it in for a 701. He just got nicely settled there, and along came the 704. Then came FORTRAN I, II, and IV; 7090's and 360's. This pioneer has more than his share of arrows, but fortunately he's in the minority!
>
> "While he was groaning, his roommate was cheering because he could now solve his problem faster, cheaper--or at all![**]

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* "LPM" means lines per minute. (Tr. 80221.)

** By the ability to solve problems "at all" Hart testified that he meant that

> "there were a number of problems that without computers could not be solved by analytical methods.
>
> "[A mathematician] could write the equation which described a particular physical situation which you wanted to study, but the equations were of sufficient complexity or the process of evaluating them was of sufficient complexity such that within any reasonable period of time no individual on a desk calculator, for example, could carry out those calculations.
>
> "That meant that in order to apply analytical techniques at all to many kinds of computer problems, the computer was a necessity." (Tr. 80221-22.)

> And many new users were attracted by new capabilities--all of the users of the 701 represent less than 1% of current users. The overall benefits [to the Computing Community] from each change have overshadowed the conversion costs required." (DX 3753 (Tr. 80191-92).)

In short, as Hart told the GM Committee on Engineering Computations,

> "Conversion costs must be taken into account when changing computers; however, in retrospect, the value of each of the above changes far exceeded the cost[s incurred]." (Tr. 80193.)*

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* Hart was referring to conversions from IBM equipment to IBM equipment, from IBM equipment to other equipment, and from other equipment to IBM equipment. (Tr. 80417-18, 81933-44.) For example, in 1976 a Honeywell computer system was moved from the Computer Science Department to another section of GM. At first all the applications that had been performed on that system moved with the system, but some of those applications returned to the Computer Science Department. That conversion "wasn't a big effort". (Tr. 80323-25.) According to Hart, very little was required "other than recompiling those FORTRAN programs on the IBM equipment and then adding to the job control language necessary to operate it in the IBM environment". (Tr. 80325.) Hart testified:

> "There is a great deal of variability in programming, from one program to another, but I am aware of the specific instances where an individual had a program running on the Honeywell equipment, moved that program over to the IBM equipment, and had it operating within the space of a day or two." (Tr. 80326.)

Similarly, conversion from the IBM System/360 Model 65 to the IBM System/370 Model 165 "was very straightforward" (Tr. 81937), but there was a "conversion problem" in going from the IBM System/370 Model 165 to the IBM System/370 Model 168 because the difference in the operating systems utilized "took us the better part of a year to complete the conversion". (Id.)

So it was in the past. The Computer Science Department's planned conversion from the IBM System/360 Model 67 to the CDC STAR-100 involved "making a great deal of investment in the basic software of the [CDC] machine in order to minimize the eventual conversion of the applications" (Tr. 81937-38); the conversion from the IBM 701 to the IBM 704 "was a difficult conversion since the programming process was different with those machines" (Tr. 81935); the conversion from the IBM 7094 to the IBM System/360 "was a difficult

Just as Hart found in 1971 that "problem solving cost has decreased by 100:1" since General Motors acquired the IBM 701 (DX 3753 (Tr. 80188); Tr. 80219) without any adjustment for inflation (Tr. 80211), Hart predicted there would be "another 100/1 decrease in problem solving cost" over the next 20 years. (DX 3753 (Tr. 80196-98).)

Asked why he was attempting to assess for General Motors what computer technology and costs will be in the future, Hart responded:

> "Clearly, technology is driving this business, where we have been involved in a business which has had rapidly changing technology from which we can conclude that the kind of computing capabilities which will be available to us ten years from now will be different from the kind of computer capabilities that we have available to us now, and that was true ten years ago, it was true twenty years ago, and it is still true today.
>
> "So, again, if we are going to provide a service for our users which provides them with modern tools and cost-effective tools, then we have to be able to assess the technological developments.
>
> "In addition, as far as our research and development activity is concerned, it is important that we pick areas for research and development which are based on reasonable technological growth. If we do research in an area where the tech-

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conversion because we were going to a completely different machine architecture" (Tr. 81936), but at that time when Hart "had looked very seriously at the GE-600 family of computers" as "alternative hardware" to the IBM System/360, he testified that "[o]ur assessment was that conversion to the GE equipment [from the IBM 7094] would have been easier [than conversion to the IBM System/360] at that point because the GE equipment was also a 36-bit word machine, much like the IBM 7094 that we were converting from". (Id.) This, of course, was GE's assessment also and was the reason GE was "overjoyed" at the announcement of the IBM System/360. (See pp. 380-81 above.)

nology is not going to change, then it may not be worthwhile. If we can see in an area that the technology is going to change, that the cost is going to go down, we can start research in an application area now which, with current equipment, would not be cost-effective in competition with the current things going on in General Motors but which, if our assessment about the future is correct, will become in fact cost-effective two years from now or five years from now or ten years from now.

"And if we determine that correctly, then we have new kinds of tools, new kinds of capabilities available when the economics are there that make it usable by the corporation." (Tr. 80394-95.)

Hart testified in 1978 that he believed that his 1971 projections about the future 100-to-1 decrease in problem-solving cost "were quite accurate" based on "what has happened over the last seven years and what I perceive as potentially happening over the next thirteen years". (Tr. 80397-98.)* Costs to computer users have come down while improvements have continued to increase for two reasons, in Hart's opinion:

"One, by providing lower cost computers, it has been possible to have more customers, more people can afford a machine of lower cost than they can of higher cost, or in general, when the cost of computation goes down, there are more people who can afford to have them.

"The other has been that the pressures have come from various groups within the industry, very competitive pressures such that each one -- each manufacturer has strived to put out a machine which would provide a useful computer for the customers and so provide a reasonable profit for the manufacturer." (Tr. 80227.)

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* The trend Mr. Hart was discussing involved a comparison of the 3033 to the 360 Model 65. Based upon public information and benchmarks run by the General Motors Computer Science Department, Hart testified that the 3033 has seven times the speed of the 360/65 and ten times the memory capacity, while the cost per problem dropped from $10 on the 360/65 to $2 on the 3033. (Tr. 80398.)

The source of that "very competitive pressure" is "vendors supplying computers". (Tr. 80227-28.)

82. Firestone

a. Introduction. Richard P. Case has been one of IBM's computer architects since the early 1960s. (Tr. 72015; see p. 269 above.)

Case testified at some length about the computer design and equipment alternatives considered by the Firestone Tire & Rubber Company, a customer with whom he had had personal discussions in 1977-1978 concerning that subject. (Tr. 73848-49.) Case noted that the "alternatives available to Firestone were representative of the alternatives that are available to very many customers". (Tr. 73881.) Specifically, he estimated the number of customers for whom all or part of the "offline and online", "centralized and decentralized and network kind of alternatives" considered by Firestone would be reasonable alternatives:

> "If you take the number of customers for which all of those alternatives are applicable, then you have first customers that have multiple locations, because a customer without multiple locations would not have a networking alternative that is reasonably applicable to him, and probably if you talk about the way in which I described Firestone and the network of regional and metropolitan centers, you are talking about a customer with locations over a reasonable geographical area, maybe not over the entire nation but over the Northeast or something like that.
>
> "The number of such customers has got to be in the hundreds if not thousands that fall in that category.
>
> "If we include -- if we eliminate the networking situation with regional centers and so forth and just talk about the various offline alternatives that I talked about plus the centralized or decentralized approach to the online situation, then the number of such enterprises increases, and I would say there are several thousand at least such enterprises.
>
> "If we go to the alternatives of online or offline and

all of the things that I talked about except not decentralized but online and offline alternatives in a centralized mode and in the changes in equipment configurations and changes in memory sizes and the CPU speeds and either separating or combining computers in one installation, all of those alternatives would apply to customers who have just one location, one or a few closely located locations, and depending upon how you count such customers and what the minimum of employees is, it goes into the hundreds of thousands of enterprises that fall into that category." (Tr. 73887-89.)

b. Firestone's EDP Installation: 1977. As of 1977, Firestone had a "large computer center" in its home office in Akron, Ohio, as well as computers in all of its manufacturing plants and in several of its warehouses. At the time, the company was also "just in the beginning of the process of installing remote terminal equipment in a large number of the company-owned retail stores and they were experimenting with different ways of delivering computing services directly to their retail stores". (Tr. 73849.)

Over the preceding ten years, Firestone had experienced a "rapid increase" in "the demands of the management . . . for greater and greater computing services". (Tr. 73850.) And the company expected that in the next five to ten years, "the total number of boxes and the total amount of computing equipment would double". (Id.) Firestone had "both IBM computing equipment and non-IBM computing equipment installed . . . in their various installations", and "many if not most of the installations were from mixed manufacturers". (Tr. 73869.)

Case's discussions with Firestone's representatives took place in the context of their evaluation of "several alternatives for accommodating the increase in capacity which they saw". (Tr. 73850.) Case understood that his discussions with Firestone data processing executives were part of their effort of "going around to different suppliers and different computer manufacturers and trying to see how they could get parts of the systems that they were considering installing from different manufacturers at the lowest possible cost". (Tr. 73869.) They were engaged "in an effort to just make sure that they really knew all the possibilities that were available, and then to pick the ones that they felt were best for Firestone". (Id.)

c. Alternatives Available to Firestone. For purposes of his discussion of the alternatives available to Firestone, Case divided the applications Firestone was processing and attempting to process into two categories: "off-line" or batch applications and "on-line" applications. He first described the alternatives under consideration for handling the increased computing capability needed to process Firestone's batch applications. They included the following:

(i) The option "to increase the number or speed of attached peripheral units on a central processing unit, for example, to increase the number of spindles of disk storage or to increase the number of tape drives or the speed of the tape drives that were installed in order that the execution of the jobs could proceed more rapidly and more work could be done in the day". (Tr. 73853.)

(ii) "[T]he possibility of increasing main memory size on the installed CPUs in order to get the higher speed that the main memory size would enable the system to operate at." (Id.)

(iii) They were "very seriously" considering "changes in software to use with their computing systems". (Id.) Case explained that some of Firestone's computers were "virtual memory configurations" and some were not. They were "seriously considering adding virtual memory software to the systems that did not already have it in order to get both the functional and speed advantages that that would be able to provide". (Tr. 73853-54.)

(iv) Firestone was also considering both of what Case called "two rather opposite alternatives": "First . . . putting in the same room with [an] existing computer installation another computer system . . . sort of side-by-side . . . and splitting the workload"; and second--"with respect to other of their installations . . . where they already had two or more computing systems installed to replace both of those computing systems with one larger computing system and consolidate the workload". (Tr. 73854-55.)

(v) Another alternative being considered was to install an IBM 3850 mass storage system in Firestone's Akron headquarters "to get the additional functional and response time characteristics that the 3850 mass storage system would be able to deliver to them and in order to reduce the number of magnetic tape drives that they had installed on that system presently". (Tr. 73855.)

(vi) Finally, "[t]hey were considering the alternative for some part of their workload of obtaining services from a service bureau . . . with remote terminals that were attached to another company's computers that were in the business of providing service to others". (Tr. 73857.)*

The second category of Firestone applications that Case discussed was that of "on-line" applications. He explained that, by late 1977, Firestone had implemented "some pilot installations" to provide "some data processing services directly at the site of the retail stores that Firestone maintained". (Tr. 73858.) The purpose was to give the retail stores "the capability of using data processing for credit collection, for customer billing, and for inventory control". (Tr. 73859.)

Prior to implementing the "pilot" installations at some stores, all of that work had been done either on a manual basis or on a "remote" computing basis--"paper forms filled out in the retail store were filled out and mailed or carried to a data processing center, and then keypunched onto cards or floppy disks, and then later entered into a computer, and printed reports would come

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* At other locations, Firestone was considering moving in-house computing work then being done by outside service organizations. (Tr. 73858.)

back in a few days or a week to the retail store". (Tr. 73859.)

Firestone's management believed that they would gain a number of advantages from implementing some form of on-line processing for the retail stores. For one thing, they would achieve "much more accurate control over the current stores' inventory", which would "reduce the total amount of capital that was tied up in inventory". Also, they would "experience fewer product outages and hence lose fewer customers because of product outages at the store". (Tr. 73860.) Another "big advantage" Firestone anticipated was the ability "to respond immediately to a customer who came up and wanted to know the balance in his account or to make payment of the account up to date". (Tr. 73860-61.) This would reduce the size of Firestone's "credit losses" and would improve customer relations. (Tr. 73861.)

At the time of Case's discussions with Firestone's data processing management, they were considering a "number of different ways" to implement on-line computing capability at their retail stores:

(i) One possibility was a "centralized" system, with "a terminal located in each store that was connected online to a central data processing center and have essentially all of the programs and all of the data kept at the central processing center, and inquiries and messages go from the terminal in the store back to the data processing center for every transaction". (Tr. 73861.)

(ii) Another option was what Case called a "decentralized" approach (Tr. 73864): "to have a computer installed at every store that was capable of keeping the records about that store's inventory and capable of keeping the records about the customers of that store at that physical location". (Tr. 73862.) Under that approach, "there would be a somewhat larger computer at every store than just the terminal" that would be used in the centralized configuration. However, in the decentralized configuration "there would be less need for central data processing services". (Id.)

Under the decentralized approach, Firestone was also considering two alternative ways "for collecting the statistics that they wanted to from a company point of view" from the individual systems at each of the stores. One way "involved just mailing some recording media like a floppy disk from the computer at the store to headquarters every week". (Tr. 73862.) The other possibility was to establish a telephone line connection between the store site computers and the central site "so that the central computer would every night . . . dial up all the branch stores' computers and get the information about the day's transactions, and then do a daily summary report". (Tr. 73862-63.)

(iii) An alternative to the "centralized" and "decentralized" configurations was a "network approach". (Tr. 73863-64.) Under that option, Firestone "would have a computer in every city where they had stores; and the computer in the city where they had stores would be connected by telephone lines to the various different retail stores in that city or in that metropolitan area, and then the computers in the different cities would in turn be connected together with the home office or the regional office and then the home office computers". (Tr. 73863.) So there would be a central computer site, four or five regional data centers, installations in each major city where Firestone has retail stores, and terminals in each of the retail stores--"with all of these computer installations connected together by telephone lines and exchanging information between them in order to accomplish the mission of serving the retail store". (Id.)

Case also explained that, however Firestone chose to configure its on-line retail store system (in a centralized, decentralized or network approach) it had to make a further design choice: "how the computing installations were going to attach the terminals in the retail stores, either how the central installation was going to do that in the centralized case or how the metropolitan installations would do that in the network case". (Tr. 73866.) One choice was "to have the terminals come through a communications control unit like the 3705 communications control unit, and then the information into the central processing unit, and have the central processing unit essentially do the processing with respect to each of the transactions that came in from the terminal".

(Id.)

Another option was to add a "front end computer" to the system. It would "do the processing on the routine transactions that came from those terminals, and have only the exceptional conditions transmitted on from that front end computer into the central processing unit computer at that same installation". (Tr. 73866-67.)

Case summarized the probable results of Firestone's overall evaluation process:

> "Now, I have to say that there was also -- we were talking about the . . . potential advantages and disadvantages of each of these three approaches to doing the retail store application, but I was clear that in actuality probably the final design of the system to serve all the retail stores would be not one of those pure three approaches but that would be some combination.
>
> "In other words, probably it would be true that some of the retail stores would have a computer themselves, some of the retail stores would have only a terminal connected to a metropolitan area installation, and other retail stores would have only a terminal connected to the central installation because there was no closeby metropolitan area installation.
>
> "So that when the -- eventually when we got all the hundreds of retail stores in the country that Firestone has connected to this system, that it would be partly centralized and partly decentralized and partly network." (Tr. 73865.)

83. Federal Government. The preceding discussion has focused on the selection and use of EDP products and services by users in the "private sector". The Federal Government is the largest user of electronic data processing products and services in the world (Wright, Tr. 13551; Shoemaker, Tr. 30702-03; DX 4355, p. 11; DX 7569, p. 5; DX 13459, p. 3) and is no different from other users in terms of the alternatives available to it, or its efforts to satisfy its data processing needs. There is substantial evidence in the record concerning the government's selection and use of computer equipment.

Each year, the General Services Administration (GSA) publishes an inventory of automatic data processing equipment--"ADP"* --in use by federal agencies.** The data show:

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* The 1978 GSA Inventory defines ADP equipment as "electronic data processing equipment (EDPE) and punch card accounting machines (PCAM.)." (DX 7634, p. 3.) It goes on to define EDP equipment as "A machine or group of interconnected machines consisting of input, arithmetic, storage, output, and control devices which use electronic circuitry, operate on discrete data, and perform computations and logical operations automatically by means of internally stored or externally controlled programmed instructions. All peripheral, or off-line data processing equipment in support of EDPE, except PCAM, is included." (Id.)

** Included in the GSA Inventory are "general purpose commercially available, mass produced automatic data processing components and the equipment systems created from them regardless of use, size, capacity, or price, that are designed to be applied to the solution or processing of a variety of problems or applications and are not specially designed (not configured) for any specific application." (DX 5703, p. 11; see DX 5201, pp. 3, 9.)

(i) In 1970, the total number of computers* in use

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* The 1978 GSA Inventory defines computer as synonymous with "CPU": "A unit of a computer system that has circuits for controlling the interpretation and execution of instructions." (DX 7634, p. 3.)

The Inventory also defines "computer system":

"A configuration of ADP equipment which includes one or more CPU's. A system can include CPU's by more than one manufacturer. The changing complexity of the technology makes it possible to interconnect CPU's and related components in a variety of ways. The following is a description of the various types of systems referred to in this document.

"Single CPU (Central Processing Unit):

"A. - One CPU and no remote equipment.

"B. - One CPU and remote equipment.

"Multiple CPU's (Central Processing Unit):

"C. - One CPU as the main processor, and one or more other CPU's (and their associated machines) as full-time peripherals or input/output (I/O) processors.

"D. - One CPU as the main processor and one or more other CPU's (and their associated machines) as part-time peripherals and as part-time independent computer systems.

"E. - Cable-connected CPU's as independent processors with shared memory and peripherals.

"F. - Cable-connected CPU's as independent processors and other remote CPU's (with their associated machines) as full-time peripherals or I/O processors.

"G. - Cable-connected CPU's as independent processors, with remote CPU's (and their associated machines) as part-time peripherals and as part-time independent systems.

within the government was 5,277. In 1975, there were 8,649; by 1978, the last year for which the GSA Inventory is available, the total had grown to 12,190. (DX 7634, p. 18.)

(ii) In 1970, the total number of manufacturers of computers in use within the government was about 45. In 1975, there were about 130 manufacturers; by 1978, the total number of computer manufacturers had climbed to more than 175. (DX 4582; DX 4587; DX 7633.)*

(iii) In 1970, the total number of manufacturers and suppliers of computers in use within the government was not less than 45.** In 1975, there were about 240 manufacturers and suppliers; by 1978, the total number had grown to more than 340. (DX 4582; DX 4587; DX 7633.)

(iv) In 1970, the total number of manufacturers of EDP equipment in use within the government was about 165.

"H. - Two or more computer systems with one system as the main system and with the other one or more separate systems as I/O processors, all under the direction of a single operational manager.

"I. - Two or more computer systems physically separate but functioning as an entity under a single operational manager, with unified input, job flow, dispatch, and control." (*Id.*, pp. 3-4.)

* All of these statistics have been taken from the GSA Inventory tapes which may include as a separately identified manufacturer or supplier companies which have been acquired by other manufacturers or suppliers. Thus, the absolute numbers may not be precise. We use these numbers not so much for the absolute level but to show the substantial growth of suppliers to the Federal Government.

** In 1970 the GSA Inventory did not include the names of non-manufacturing suppliers.

In 1975, there were more than 530 manufacturers; by 1978, the total had grown to over 700. (DX 4582; DX 4587; DX 7633.)

(v) In 1970, the total number of manufacturers and suppliers of EDP equipment in use within the government was not less than 165. In 1975, there were more than 650 manufacturers and suppliers; by 1978, the total had grown to over 875. (DX 4582; DX 4587; DX 7633.)

The GSA Inventory also shows how individual suppliers have successfully increased their marketing activities to the government. For example:

(i) In 1970, there were 499 DEC computers reported in use at various federal agencies. By 1978, the total number of DEC computers had increased to 2,992, almost six times as many. (DX 4591, p. 18; DX 7634, p. 21.) Since 1975, DEC has had more computers installed in the Federal Government than any other supplier. (DX 924, p. 6; DX 4596, p. 6; DX 4729, p. 21; DX 7634, p. 21.)

(ii) Honeywell had 299 computers reported in use at federal agencies in 1970. In 1978 there were a total of 891 Honeywell computers, almost three times as many. (DX 4591, p. 18; DX 7634, p. 21.)

(iii) Univac had 1,198* computers reported in use at

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* This number includes 184 RCA computers installed in the government in 1970. (DX 4591, p. 18; DX 7634, p. 21.) We include these in Univac's numbers for 1970 because some may have been included in the 1978 Univac numbers reported by GSA.

federal agencies for 1970. In 1978 the number of Univac computers was 1,749, an increase of more than 45%.

(iv) Burroughs had 204 computers reported in use at federal agencies in 1970. By 1978, there were a total of 272 Burroughs computers, a 33% increase. (DX 4591, p. 18; DX 7634, p. 21.)

(v) CDC had 404 computers reported in use with federal agencies in 1970. In 1978 there were a total of 492 CDC computers, an increase of 22%. (DX 4591, p. 18; DX 7634, p. 21.)

There are also companies which had only a few or no computers in federal agencies in 1970, but which, by 1978, had a large number of computers in use. For example:

(i) Data General had seven computers in use within the government in 1970. By 1978, the government had 891 Data General computers. (DX 4591, p. 173; DX 7634, p. 21.)

(ii) Hewlett-Packard had 41 computers in use within the government in 1970. By 1978, the government was using 814 Hewlett-Packard computers. (DX 4591, pp. 184-85; DX 7634, p. 21.)

(iii) Modular Computer Systems, Inc. had no computers in use within the government in 1970. In 1978, the government was using 359 Modular Computer Systems computers. (DX 4591, p. 219; DX 7634, p. 21.)

The Inventory shows that IBM was somewhat less successful in its marketing activities to the government. For example:

(i) The number of IBM-manufactured computers in use within the government declined during the 1970s. In 1970, there were 1,397 IBM computers in use within the federal government; by 1978, the number had declined to 1,179, a decrease of more than 15%. (DX 4591, p. 18; DX 7634, p. 21.)

(ii) The percentage of the total number of computers in use within the government which were manufactured by IBM declined during the 1970s. In 1970, it was 26.4%; by 1978, it had fallen to 9.7%, as compared to 24.5% for DEC and 14.4% for Univac. (DX 7634, p. 21.)

(iii) The percentage by value of computers in use within the government which were manufactured by IBM also declined during the 1970s. In 1974 (the first year these data were available), it was 33%; by 1978, it had fallen to 28%. (DX 4595, p. 19; DX 7634, p. 33.)

(iv) The percentage by value of "storage units", "input/output units" and "communications terminals" in use within the government which were manufactured by IBM declined during the 1970s. In 1974, it was 39%; by 1978, it had fallen to 26%. (DX 4595, p. 19; DX 7634, p. 33.)

(v) The percentage by value of all computer equipment in use within the government which was manufactured by IBM declined during the 1970s. In 1974, it was 37%; by 1978, it had dropped to 27%. (DX 4595, p. 19; DX 7634, p. 33.)

As we have discussed earlier, on February 2, 1970, the Bureau of the Budget (later renamed the Office of Management and Budget) issued Bulletin No. 70-9, which required federal agencies to review all leased peripheral equipment in use within the government to determine which products should be replaced by less expensive equipment from independent peripheral manufacturers or other sources. A substantial number of IBM peripherals were replaced as a result of this directive. (See, e.g., DX 6257, Gold, pp. 113-14, 130-31; DX 4555.) For example:

(i) By 1971, more than 550 IBM disk and tape drives were replaced with competitive equipment in various federal departments and agencies, including the Army, Air Force, GSA, National Oceanic and Atmospheric Agency, Railroad Retirement Board, Office of Economic Opportunity, SEC, Commerce Department, Government Printing Office, Defense Communications Agency, Library of Congress and Social Security Administration. (DX 4417, pp. 31-35.)

(ii) Also by 1971, the Navy replaced more than 1000 IBM disk and tape drives, reportedly saving approximately 13 million dollars over the following three years. (DX 5127.) More than 60 different companies had received requests for proposals from the Navy, and 14 responded. (DX 5136, pp.

1-2, 13.)

During the 1970s, the government's increased use of plug-to-plug compatible peripheral equipment, the increasing success of new and established suppliers in marketing to the government, and the GSA's emphasis, beginning in 1971, on soliciting multi-year EDP leases with discounts (see Cary, Tr. 101671-73; DX 4381, p. 1; DX 5136, p. 2; see pp. above), led to the Federal Government's increased use of "mixed systems". Various federal agencies which had systems entirely comprised of IBM equipment in 1970, had switched to mixed systems by 1978. For example:

(i) The Administrative Division of the F.B.I. had an IBM System/360 Model 40 and an IBM System/360 Model 50 in 1970. Both CPUs had associated peripherals supplied entirely by IBM. (DX 4582, pp. 2029-30.)

By 1978, the Administrative Division had three IBM 360/65s, but all were supplied by a leasing company. Moreover, the Division's systems used peripherals, including tape drives, disk drives, drums, terminals and other input/output devices, supplied by several companies. They included Storage Technology, CalComp, Telex, Itel, Univac and IBM. (DX 7633, pp. 4844-49.)

(ii) In 1970, the Headquarters of the Marine Corps in the Department of the Navy had an IBM System/360 Model 65 with peripherals supplied entirely by IBM. (DX 4582, pp.

1724-26.)

By 1978, the Marine Corps still had a Model 65, but with a larger number of peripheral units, supplied by various vendors, including CalComp, Itel, Ampex, Telex, Mohawk, Memorex and IBM. (DX 7633, pp. 4025-27.)

(iii) The Office of Assistant Secretary for Administration, Data Processing Center, Department of Labor, had in 1970 an IBM System/360 Model 65 and peripherals, all supplied by IBM. (DX 4582, pp. 2034-35.)

By 1978, the Data Processing Center still had a Model 65, but it was supplied by a third party. Further, there were many more peripheral units, supplied by a number of vendors, including IBM, Ampex, Storage Technology, CalComp, Itel and leasing companies. (DX 7633, pp. 4917-20.)

(iv) In 1970, the Railroad Retirement Board had two IBM System/360 Model 50s, with peripherals supplied entirely by IBM. (DX 4582, pp. 2269-70.)

By 1978, the Railroad Retirement Board had an IBM System/370 Model 155, along with a larger number of peripherals, supplied by IBM, Storage Technology, CDC, Itel, Memorex, Ampex and others. (DX 7633, pp. 5449-51.)

In addition to the proliferation of mixed systems during the 1970s, those responsible for procurement of EDP products and services for federal agencies recognized the increasing capabilities of "minicomputers" for handling the government's EDP requirements. For example:

(i) Clark R. Renninger of the Institute for Computer Science and Technology of the National Bureau of Standards, in a speech before the 7th Conference, Intergovernmental Council for ADP in Ottawa, Canada, in 1973, stated:

> "Advancements in computer technology have considerably altered the pattern of computer use; and the widespread popularity of minicomputers, the impact of teleprocessing, and other developments are now forcing an examination of the best way to deploy our data processing resources." (DX 5369, p. 1; see DX 5422, pp. 220-223.)

(ii) Mr. Renninger's supervisor, Dr. Ruth M. Davis, the Director of the Institute for Computer Science and Technology, stated that, by 1973, minicomputers were an increasingly important alternative considered by the government:

> "As the focal point for computer technology in the federal government, we in the Institute for Computer Sciences and Technology have a special interest in minicomputers. . . . We have seen minicomputers expand their utility from dedicated applications to general purpose systems to systems components in large-scale computer networks. We have seen the federal procurement of minicomputers grow to the point where 48% of the systems acquired in the past fiscal year [1972] were minis (as compared with 38% in the previous year). We have seen the minicomputer market grow to its present level of $400-500 million per year, with more than 50,000 minis installed worldwide. We have seen new firms enter the minicomputer field--and a few leave--so that there are new [sic] now about 50 different companies manufacturing minicomputer main frames." (DX 5346, pp. 1-2.)

(iii) Douglas A. Crone, Deputy Director of ADP Procurement for the GSA, testified in 1973 that minicomputers were an important alternative for the GSA to consider when it procured computer equipment. He stated:

> "there's a wider range of computer capability available, and you use, now, the capability that matches what you need. In some instances, it's more economical to provide a mini-computer at a number of -- or several mini-computers at a number of locations rather than have a centralized, large system. . . . Other times, even today, it's better to have a centralized system with terminals. I mean, a lot depends on your applications. . . . It has opened up the choice of 'Shall you have one big system, or a number of systems with terminals,' or 'Do you want to decentralize to small systems'." (DX 9071, Crone, pp. 130-31.)

The alternatives of plug-compatible peripheral equipment, leasing company-supplied equipment and minicomputers are among a much larger number of options which the government considers in making EDP procurement decisions. For example, the procurement policies of the Atomic Energy Commission illustrate the breadth of alternative sources for EDP products and services available to, and considered by, federal agencies:

> "Generally, AEC ADP procurement decisions are and have been made, in the best judgment of responsible AEC and contractor officials, on the basis of which ADP equipment meets the requirements at the lowest overall cost."
>
> ". . . .
>
> "The general ADP alternatives considered by AEC include:
>
> "(a) utilization of excess equipment;
>
> "(b) sharing of existing equipment in AEC and other Government agencies;
>
> "(c) purchase or lease; and
>
> "(d) use of commercial ADP services."

"ADP suppliers considered by AEC as sources for some of these general alternatives include:

"(a) suppliers of ADP equipment for purchase or lease, including:

"1. firms selling or leasing new equipment;

"2. firms selling or leasing used equipment;

"3. to a very limited extent, firms leasing a manufacturer's equipment at lease rates lower than those obtainable from the manufacturer;

"4. suppliers of ADP equipment for purchase or lease which is to form part of a system with ADP equipment to be supplied by another firm(s) at about the same time or which becomes part of a system by adding to or replacing ADP equipment previously supplied by another firm(s), including:

"(i) suppliers of peripheral ADP equipment 'plug-compatible' to another manufacturer's equipment;

"(ii) suppliers of ADP equipment which becomes part of an ADP system, other part(s) of which are manufactured by another manufacturer.

"(b) suppliers of ADP services, including:

"1. AEC suppliers;

"2. other United States government suppliers; and

"3. private sources." (Plaintiff's Admissions, Set IV, ¶¶ 14.1, 15.2, 15.3.)

Elliot Gold, Acting Director of the ADP Procurement Division of GSA, testified in 1974 concerning the various alternatives considered by the GSA in making EDP procurement decisions. (DX 6257, Gold, pp. 1-2.) Gold testified that before the GSA decides to acquire computer equipment from a vendor, "all alternative sources of supply" are considered, including peripheral equipment manufacturers, systems manufacturers, leasing companies, the government's excess equipment, time sharing firms and brokerage firms. (Id., pp. 108-09; see DX 5369, pp. 1-2; DX 5708; DX 7528, Mahoney, pp. 104-06; DX 9071, Crone, pp. 43-44, 48-50, 59, 147-48.)

Similarly, the plaintiff has admitted that GSA and other government agencies "usually consider a variety of alternatives before they make a procurement determination", and take the following into consideration:

> (a) "Prior to acquiring EDP products or services, GSA or Government agencies usually consider whether their needs can be met by using EDP products and services owned or controlled by the Federal Government."
>
> (b) "Government agencies sometimes consider time sharing services offered by GSA or private companies and service bureaus as an alternative to installing their own computer system."
>
> (c) "Federal procurement regulations and policies require Government agencies [to] consider as alternatives EDP products and services from Government excess inventory and joint use centers."
>
> (d) "Government agencies sometimes consider as alternatives EDP products and services from leasing companies, used equipment brokers and dealers."
>
> (e) "Government agencies consider acquiring EDP products and services which comprise complete systems and consider individual devices which can be used with EDP products currently in use at the agency."
>
> (f) "A number of EDP suppliers market EDP devices which can be used with the EDP equipment of other manufacturers including IBM."
>
> (g) "Government agencies consider acquiring software from the manufacturers of the hardware or from vendors of software."

(h) "Government agencies consider acquiring maintenance services from the manufacturer of the EDP equipment or from firms engaged in servicing equipment and consider using Government personnel to perform that service."

(i) "There are many courses of action that GSA and Government agencies pursue to reduce the cost of EDP operations."

(j) "Usually there is a variety of EDP products available to perform a data processing application."

(k) "In some instances, the user has, among others, a choice of one big system, a larger number of smaller systems with terminals or an even larger number of small systems using smaller computers."

(l) "There are a number of EDP hardware products which can be configured to do the same applications in different ways and with different costs."

(m) "In some instances reprogramming existing EDP equipment has avoided the need for acquiring additional hardware."

(n) "Operating systems which give better utilization of hardware can improve processing efficiency and avoid the need for additional hardware capacity." (Plaintiff's Admissions, Set II, ¶¶ 357.7-358.5, 358.7.)

84. IBM Account Studies. Several IBM memoranda from the mid- and late 1970s, about which John Akers, IBM Vice President and Group Executive of the Data Processing Marketing Group, testified, complement the testimony by the computer users discussed above concerning the data processing options available to them and others.

a. "Large Systems Product Plans". Defendant's Exhibit 9399 is a copy of a 1975 presentation, entitled "Large Systems Product Plans", which was made to Akers when he was President of IBM's Data Processing Division by his Systems Marketing staff "regarding their perspective of the product plans for large systems, large processors". (Tr. 96873.) The purpose of the presentation was to provide Akers with his staff's "assessment of those plans and update [him] regarding the work that they had performed in an effort to communicate as effectively as possible regarding what [IBM's] Data Processing Division felt those plans should be". (Tr. 96873-74.)

Akers was evaluating IBM's large system plans in 1975 because the company was then "experiencing substantial competition from a number of areas, including plug-compatible processor competition which was being shipped now for the first time in the United States, [and] including small systems competition. . . ." (Tr. 96875.)

Part of the presentation dealt with the results of a "very detailed review of one hundred or more accounts" visited in the course of the study, during which the customers' "data processing plans" were reviewed. (Tr. 96874.) Akers testified:

> "As a result of their visits with those one hundred customers--one hundred nineteen, to be exact--they found 64% . . . were currently considering offloading. . . .
>
> ". . . .
>
> "The net . . . is that two-thirds of one hundred of the largest users of IBM's large processors were actively considering alternatives to doing their work other than with large processors. . . ." (Tr. 96886-87.)

Akers added that the customers were considering three types of off-loading:

(i) "new applications that currently are not on those central site processors";

(ii) "the removing of workload from the processors to the communications controllers, and that's what 'front-ending' means"; and

(iii) "the decentralization or the removal of some or all of the applications that were being performed on those large processors". (Tr. 96887.)

Akers explained the effect of off-loading on the equipment utilization of the customer's large computer system:

> "If work is removed from a large computer system, the utilization of that computer system is reduced. And much of the examples we are talking about here, that's exactly the drive, to reduce the amount of utilization that the processors centrally are experiencing, or the utilization of the processors are significantly high that additional work couldn't be added without adding additional resource, that is, more processor capability and more input/output equipment.
>
> "And as the customer gets to the point where his resource

is full, the alternative of more resource in that approach, or alternative resource in small processors, as we are discussing here, are obviously one of the things they are considering." (Tr. 96902-03.)

The Large Systems study identified examples of customers who were considering off-loading: Marine Midland Bank; Time, Incorporated; Chemical Bank (who, it is said, "will switch to intelligent front ends"--as, of course, Chemical did with the installation of its Collins C-900 configuration, see pp. 1349-50); Los Angeles County; the Social Security Administration; the CIA; Merrill Lynch; Rockwell; Combustion Engineering; the State of Kentucky; Hercules; Shell Oil; and Hartford Group Insurance. (DX 9399, p. 12.)

Akers explained the situation at several of the customer accounts. For Marine Midland Bank, the study reports it "will go DEC like B of A and Security Pacific did". (Id.) Akers explained:

"Marine Midland Bank in New York was planning at this time, considering doing part of their work in the way in which both B of A, the Bank of America, and Security Pacific National Bank had already made decisions, and that is, those two situations were the following:

"Those two banks were performing work on large IBM processors as part of their 370 systems, our 168 processors, to be specific.

"They wished to add more work to that which was already being done.

"They considered, among the alternatives, 168 processors from IBM and the aggregation of multiple small processors from IBM and from other people.

"Both the Bank of America and Security Pacific National Bank chose to proceed with multiple small processors as opposed to the 168 recommendations that the IBM Company had made.

"They were both significant competitive losses on the part of the Data Processing Division that had occurred just before this particular presentation. . . ." (Tr. 96887-88.)

For Merrill Lynch, the study states, "trend established with 5 Comten installed". (DX 9399, p. 12.) Akers explained:

"Well, Merrill Lynch and IBM have done business together for a long time and I have met with them from time to time.

"Comten is the name of a product that is plug compatible with communications products offered by the IBM Company, plug compatible with the 3705, to be specific, as one example, and this indicates that Merrill Lynch has five installed and seems very satisfied and is going to do more of that." (Tr. 96897-98.)

For Rockwell, the study indicates, "Will off-load MIPS to relieve TSO constraint". (DX 9399, p. 12.) Akers explained:

"That means that Rockwell International is performing work with a software product entitled TSO, which stands for Time Sharing Option, which is simply a way of programming the use of the computer system.

"This suggests that the processor is full and more work is not possible in that processor, and that Rockwell believes the plans to remove some of that work and perform it not in that processor but in alternative processors is the thing that they should do." (Tr. 96898.)

For Shell Oil, the study states, "Distributed processing is attractive form of offloading". (DX 9399, p. 12.) Akers explained:

"That's the same kind of thing we were talking about with Security Pacific National Bank where processing in the bank is done, some of it, in one location and some of it in other locations throughout that enterprise. And Shell is considering doing processing in multiple locations, and in doing that some of the work that is currently being done in the location being referenced here would be potentially done in other locations." (Tr. 96900-01.)

For Hercules, the study reports, "Offloading will reduce exposure to unavailability." (DX 9399, p. 12.) Akers explained:

> "[W]hen an individual terminal requires the computer resource to be available to do his work and it is unavailable, something is wrong with that resource, whether it be the communications lines, or the application program a customer wrote, or the hardware or software provided by the vendor is not working, and the complexity of larger systems often leads to the unavailability of that system from time to time to the user.
>
> "This suggests that Hercules believes that an alternative to that large system will reduce that unavailability of that computing resource to the user." (Tr. 96901.)

The "Large Systems Product Plans" study also focused on plug-compatible processor competition at the selected 119 accounts. The study found that 40 percent of the accounts were then considering the "plug-compatible processor alternative" (Tr. 96905; DX 9399, p. 13), and there was plug-compatible "sales activity", specifically by Amdahl, "in virtually all of [the] 119" accounts. (DX 9399, p. 13.) As Akers testified:

> "At this particular time, our customers were enjoying the opportunity of large processors available from Amdahl that were both better performance and better priced than IBM's processors and were enjoying the multiple small systems offerings that we have now discussed at some length. . . . And so that we were getting severe competition from two very distinct and different alternatives, namely, Amdahl and the alternative of small systems in offloading work as we have been discussing now for some time, and that there was substantial competitive activity in 119 accounts that this team visited." (Tr. 96905-06.)

b. <u>"Minisystem Highlight Reporting--Account Profiles".</u> Another IBM document discussed by Akers was "a compendium of work done by representatives of the Data Processing Division during 1975 that studied the utilization of minicomputers, small computer systems, by ten enterprises in the United States". (Tr. 96839.)

That document is entitled "Minisystem Highlight Reporting--Account Profiles" and a copy is Defendant's Exhibit 9403.

Akers, who was President of the Data Processing Division at the time and commissioned the work, sent the study to ten high level IBM executives (see Tr. 96843-44; DX 9403, p. 2) because it was his

> ". . . strong desire to communicate in detail and specify the environment in which small computers were being utilized in 1975 in order to do a better job of communicating my customers' needs to the various people in the IBM Company that dealt with our product line, because I believed we needed to do a number of very important things to improve our product line." (Tr. 96839.)

Akers began the project because of "several concerns" he had at the time: ". . . although we had been studying competition of this sort for some time, the level of knowledge that resided inside IBM, in my opinion, continued to be superficial"; ". . . the activity that was going on in the marketplace was not being reported to any degree at all in the process that the IBM Company was employing". Akers was "very disappointed with the progress that was being made in improving our product line and I wanted to have detail with which I could communicate and negotiate". (Tr. 96840.)

The ten customer accounts discussed in the "Mini-system Highlight" report "were selected to be representative of the marketplace that were institutions of considerable size, that were customers of the IBM Company, and that had had some considerable experience in the utilization of small systems". (Tr. 96842-43.)

Akers summarized what the study had found in the ten representative accounts it had examined. He testified that all of the customers were saying "essentially the same thing":

> ". . . that there are opportunities to use small computers, and as those small computers have gained in capability I am using them more and more . . . that I am pleased with the ease with which I can install them, I can quickly begin to get payback, they are easy to operate. I intend to upgrade them. I am spending a good deal of money in this project today; I intend to spend more tomorrow. And very often and usually, the IBM Company's product line has been judged to be deficient." (Tr. 96849.)

Among the specific customer accounts examined in the report were the following:

(i) <u>First National City Bank (Citibank)</u>

According to the study:

> "The bank's philosophy with minisystems is to distribute the workload now on the central system to each of the 36 bank 'channels' (operating processes). The channels are broken into the smallest business entity, so that each channel can have tight control of the work process while maintaining a manageable unit. Each channel will have its own minisystem which will not communicate with a central computer. The bank believes that communications between channels will evolve naturally through improved technology." (DX 9403, p. 29.)*

As of the time of the account review, Citibank had 23 "minisystems" installed and an additional twenty planned. The vendors involved included: TTI (Scantlin), REI, DEC, Interdata, Data General, General Automation and Qantel. (<u>Id.</u>, p. 28.) The applications for which the various "minisystems" were being used (or were planned to be used) at Citibank covered a broad range of banking related activi-

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* As noted, Welch of Chemical Bank gave a similar description of Citibank's data processing views. (See p. 1344 above.)

ties: electronic credit authorization; portions of check processing communications control; timesharing; automatic message verification; stock transfer data entry; international money transfer; New York City tax data entry; securities processing; commercial loan processing; and foreign exchange. (Id.)

Citibank's first "minicomputer"-based system, a Scantlin 801, was installed in 1972 as part of an effort to develop a credit authorization system. By the time of IBM's study, Citibank had installed approximately 5,000 "Citicard Terminals" in branch bank and merchant locations, all linked to Scantlin 801 processors. (Id.)

In 1973, Citibank installed its first "minisystem" for "back office" banking automation. According to the study, "[i]t was used to interface REI [Recognition Equipment, Inc.] check sorters to the bank's Burroughs B 3500 check processing system and enabled the bank to decentralize the check processing function into those departments where check input originates". (Id.)

In 1974, the year preceding the IBM study, IBM had 38,700 points--that is, dollars of monthly rental--installed at Citibank; from 1970 to 1974, IBM had averaged about 67,000 points installed. (Id., p. 27.) Citibank's installed "minisystems" as of 1975 had an approximate value of 30,000 points, based on IBM's estimates, and the planned "minisystems" represented approximately 37,000 additional points. (Id., p. 29.) The study noted that "[a]s a result of their emphasis on decentralization, Citibank had made no major IBM decisions for 18 months." (Id., p. 30.)

(ii) J. C. Penney

Akers summarized the situation of J. C. Penney in 1975:

> ". . . I learned that this very fine IBM customer, and who we had been doing business with for years, was using a lot of our equipment, a lot of our products and services, was also using an enormous number of small computers from other vendors. The product line that was being marketed at J. C. Penney, was being accepted by them for much of their work, was judged by them to be not as good as other alternatives that were being marketed by IBM competitors. The J. C. Penney Company is in the business of merchandising, and to be effective they need to manage their store operations in a very careful way, and the application of small computers in the thousands of J. C. Penney stores across the country was a key part of their business strategy, and they were executing that business strategy fundamentally without IBM products because they judged other alternatives to be better.
>
> "And that . . . is an excellent example of the great frustration I was feeling as the sales leader of the Data Processing Division in being unable to get business from J. C. Penney because the other fellows in the marketplace were marketing products that J. C. Penney thought were better. (Tr. 96848-49.)

Specifically, the IBM study reported that users of data processing within J. C. Penney believed that the "[u]se of 'distributed intelligence' allows the processing capability to be located where the need and line management responsibility exists". (DX 9403, p. 33.) Those users saw a number of advantages in the use of small processors to distribute intelligence within the system, including: "Reduces vulnerability to downtime"; "Relieves some operations responsibility from data processing"; and "Allows development load to be shared by others (systems integrators/vendors)". (Id.)

(iii) Massachusetts General Hospital

The IBM study also indicated that as of 1975, this hospital had competitive "minisystems" installed from DEC, Sanders, Inforex and Xerox. (Id., p. 37.) The equipment was used for: medical information systems and laboratory support (DEC), control and analysis of nuclear brain scans (DEC), intelligent CRT control (Sanders), clustered data entry (Inforex) and patient heart monitoring (Xerox). (Id.)

According to the IBM study, after an IBM System/370 Model 145 was installed in late 1975, replacing two purchased 360/40s, IBM equipment at the hospital would have an approximate value of 45,000 points. (Id., p. 36.) The value of the hospital's installed "minisystems" was estimated to be about the same, roughly 45,000 points. (Id., p. 37.)

(iv) The Equitable Life Assurance Society of the United States

The Equitable began installing "minicomputers" in 1972 for processing group health claims. By 1975, it had 195 systems installed, working on group health claims as well as: group compensation processing, Medicare claims data entry, group premium data entry, word processing, computer center data entry, communications support, remote job entry and investment analysis. (Id., pp. 52-53.) The customer classified 58 percent of its minicomputer work as "commercial processing", 36 percent as "intelligent data entry" and 6 percent as "communications". (Id., p. 53.)

According to the study, one explanation for the customer's rapidly increased use of minicomputers was the fact that:

> "[s]ince 1971, Equitable has been involved in the complex hardware/software migration required for moving from an IBM 7080 to an IBM VS environment. The constant change has had a negative effect on service to user departments, causing them to seek alternative solutions to their problems to get short term payback." (Id., p. 51.)

c. "Low End Productivity Analysis". Defendant's Exhibit 9409 is a copy of a 1978 IBM account study entitled, "Low End Productivity Analysis", which was done by Akers' staff at the Data Processing Marketing Group and focused on the "ease of use and ease of installation of small systems". (Tr. 96963.) Akers explained the reason for the study:

> "The subjects of ease of use and ease of installation and amount of work that needs to be done both by the vendor and by the customer are subjects of paramount importance to me and to our customers.
>
> "I felt that we were not doing the job that needed to be done competitively in the area of ease of installation and ease of use and that work was done with that in mind." (Id.)

The "Low End Productivity Analysis" was "the result of an extended piece of work studying the utilization of small systems by 40 companies, some of whom have successfully installed IBM small systems, some of whom have successfully installed competitors' small systems". (Tr. 96964.) The study was intended to "illuminate" ease of use, operation and installation features which could then influence IBM's product plans. (Id.)

Akers explained the conclusions he drew from the information presented in the study:

> ". . . the customer pursued the alternative of small systems for a variety of reasons:
>
> "To offload his processors . . .; in order to perform the application in a more effective way from the user's point of view; in order to gain those improvements faster by the installation of small systems as opposed to the installation of those applications improved on the central site; that when installing competitive equipment the customer usually enjoyed productivity over and above that which he had experienced with IBM in many cases; that our competitors had been successful in making their small systems easy to install, easy to use and, as such, the benefits accrued to the customer from that installation happened very rapidly." (Tr. 96966-67.)

As noted, the Low End Productivity Analysis focused on 40 selected customer accounts, including these:

(i) Southwest Bell Telephone

Southwest Bell reportedly uses a DEC PDP 11/70 to supply central repair bureau employees with the records of customers (displayed on CRTs) who call in for repair services. The PDP 11/70 then communicates to a 370/168 which "puts out a trouble report and customer record on a remote printer at the repair bureau". (DX 9409, p. 90.) IBM had "proposed a 168 solution with dumb terminals. However, Bell Labs said that 168 with dumb terminals couldn't handle the workload. . . . Bell Labs . . . decided that the large volumes involved could be better handled on a dedicated 'mini'". (Id.)

(ii) Dow Chemical

Dow is said to have installed two General Automation 440s to perform "administrative" applications, such as payroll, personnel data and cost accounting, on a standalone basis. According to the study, "[t]his installation is typical of the trend within Dow for smaller units to have their own DP capability rather than sharing another unit's larger system". (Id., p. 92.)

The administrative applications were previously done on a 370/155 belonging to another division of the company.

> "Problems associated with the overloading of this 155 led to the creation of a new DP Manager job for the 'guest' division 155 user. The new DP manager, taking his cue from the General manager who liked 'minis', decided on a 'mini' approach to offload from the 'host's' 155 his own major administrative applications." (Id.)

With respect to the selection of General Automation, the study reported that Dow's "prime requirement was the availability of ANS COBOL". General Automation offered that capability, its price was "the next to lowest of 8 'minis' they looked at", it "promised full time on-site software support for 2-3 months", and "[m]aintenance was also readily available through the regional GA office in Houston". (Id.)

(iii) Procter & Gamble

Procter & Gamble installed two Hewlett-Packard 3000 systems--selected from among 20 vendor proposals--as the initial stage in a program to distribute data processing functions, such as data entry and edit, from Procter & Gamble's central data processing site. (Id., pp. 111-12.) Procter & Gamble has chosen to use "minicomputers" for functions common to many applications. "Any application" requiring the off-loaded functions "is a candidate for distributed data processing". (Id., p. 111.)

Procter & Gamble is said to have decided on the "minicomputer" approach for several reasons: "[l]ower cost of DP solutions through distributed data processing"; "[s]implicity of implementation and operation"; and the fact that "[t]he number of end users is growing more rapidly than the central DP department can support". (Id.) The "central DP organization" proposed that it do "some parts" of the work off-load to the minicomputers, but, according to the study, "these proposals never got very far because the standard IMS kind of implementation was felt to take much too long". (Id.)

(iv) Pepsi-Cola General Bottling

According to the IBM study, Pepsi Bottling decided to install a Datapoint 6600 at each of ten remote division locations, all linked to a centrally located 370/138, to generate route settlement, payroll, accounting, general ledger and sales analysis reports to Pepsi Bottling's holding company and to the government. (Id., p. 115.)

The Datapoint 6600/138 configuration was selected after reviewing various approaches and vendors. According to the study, "[h]igh communication line costs contributed to a distributed solution". (Id., p. 116.)

(v) Northwestern Mutual Life Insurance Co.

Northwestern Mutual installed 113 Texas Instruments 960 Systems at agent offices around the country. (Id., p. 124.) The TI-supplied equipment performs policy inquiry, sales proposal, new business and message switching applications. (Id.) The remote systems access a larger Texas Instruments 960 "which acts as network controller and handles remote unit hardware and software diagnostics". (Id.) The entire network, in turn, is linked to a 370/168 which maintains the company's account data base. One "agency stand-alone application", general accounting, was not performed in conjunction with the 168 and was added to the TI equipment shortly before the IBM study. (Id.)

The report explained Northwestern Mutual's decision to implement a "minicomputer approach":

> "The initiative to change from the previous semi-automated approach originated with the ultimate end-users, in this case the insurance company's sales force pressing the home office to maintain an industry leadership role in DP. The decision to go to a 'mini'-computer solution came from the DP department, which viewed the 'mini' as a product breakthrough, overcoming the cost disadvantages of the on-line terminal approach. . . ." (Id.)

(vi) Standard Oil of Indiana

Standard Oil installed a Modcomp IV computer system to perform a plant maintenance application. "The user department enters work orders and receives printed schedules from the system which both updates the inventory of maintenance work, sorts, and schedules the load by location, labor skill and priority." (Id., p. 127.) Another Modcomp IV system, which shares the disk storage of the first, supports plant process microprocessors and instrumentation.

The Modcomp equipment was acquired because Standard Oil's maintenance department wanted to expand the plant maintenance application and bring it on-site, that is, to the plant: "Previously the application had been partially run in batch mode in [Standard Oil's] large (3-370/168) Corporate Data Center with the balance performed manually." (*Id.*)

85. Conclusion. Stepping back from the numerous individual competitive product announcements and customer procurement decisions which took place in the Seventies, we can see two important trends over the past three decades of the EDP industry.

The first, and one that hardly needs further elaboration, is the increase in the number of suppliers in the industry and, more importantly, the increase in the number and diversity of product and service alternatives those suppliers have been compelled to make available to customers. From a handful of suppliers in the 1950s offering what from today's perspective was quite limited and primitive equipment, the industry has expanded impressively in sources of supply and in product and service.

The second is the rapid rate of technological change that drives the industry's participants and is driven by them.

Improvements in computing capabilities, as reflected by raw measures of performance, particularly when considered with product prices, underscore some of the major advances achieved by computer equipment manufacturers over the past three decades.*

(i) The multiplication rate of processors, measured in their ability to execute multiplications per second, has been increased by a factor of 1,400 from the IBM 701, announced

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* The comparisons do not take into account the inflation rate over the past three decades. Based on the Department of Commerce's Index of Prices for Producers' Durable Goods, a rough calculation indicates that price levels have increased between 1952 and 1979 by a factor of over two and one-half.

in 1952 to the IBM 3033, announced in 1977, for a rental price that has increased only 5 times. (See Andreini, Tr. 47581, 47694-95; Case, Tr. 74220-24; Hart, Tr. 80187; Hurd, Tr. 86362; DX 9405, pp. 553, 556-57.)

(ii) The instruction rate, measured by the number of instructions that can be processed per second in a typical instruction mix, has been increased by a factor of 1,100 from the IBM 650 in 1953 to the IBM 4341 processor in 1979, at less than a 3 times rental price increase. (Akers, Tr. 96692; DX 4740, Evans, pp. 4034-35; DX 1402; DX 4755; DX 9395, p. 4; DX 9405, pp. 1049-50.)

(iii) The capacity of computer main memory has been increased by a factor of 800 from IBM's 701 to the 3033 and by a factor of 400 from the smaller IBM 650 to the IBM 4341. (Hart, Tr. 80187; DX 1402; DX 9405, pp. 553, 1044, 1048.)

(iv) The price of one million bytes of main memory for the 4341 is 1/500 what it was for the IBM 701 and 1/238 what it was for the IBM 650. (DX 1402; DX 9405, pp. 1013, 1044, 1049; DX 13367.)*

(v) The storage capacity of magnetic disks, per spindle, has been increased from 4.4 million bytes on the IBM 350 disk

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* The first generation processors could not, of course, handle anything approaching one million bytes of memory. The 701, for example, could have at most about 4 thousand "words" of memory, which was roughly equivalent to less than 20 thousand bytes. (Hurd, Tr. 86354-57; see also Case, Tr. 72248; Crago, Tr. 86175.)

of 1956, to 25.87 million bytes on the IBM 2314 disk of 1965, to 100 million bytes on the 3330 of 1970, to 317.5 million bytes with the 3350 of 1975, to 1.26 billion bytes with IBM's 3380 in 1980. (Case, Tr. 72738, 72743-45, 72747; DX 3554D; DX 1437; DX 9405, pp. 174, 178; DX 14297.)

(vi) The data transfer rate achieved by disk drives, measured by the number of bytes transferred per second, has been increased by a factor of 136 from the IBM 350 to the IBM 3350, 211 times from the IBM 350 to the IBM 3370, and 341 times from the IBM 350 to the IBM 3380. (Case, Tr. 72739, 72747; PX 6072; DX 3554D; DX 9405, pp. 174, 178, 1055, 1058; DX 14297.)

(vii) The price of disk storage has been reduced: with the 350, one rental dollar bought 6.8 thousand bytes of disk storage; with the 2314, a rental dollar bought 38.2 thousand bytes; with the 2319, a rental dollar bought 82.6 thousand bytes; with the 3330, one rental dollar bought about 145.6 thousand bytes; with the 3350, a rental dollar bought 470.0 thousand bytes; with the 3370, a rental dollar bought 810.3 thousand bytes; and with the IBM 3380 a rental dollar bought 1.19 million bytes. (Case, Tr. 72738; Haughton, Tr. 94860; JX 38, pp. 440, 451; PX 4527, pp. 1-2, 5; DX 1437, pp. 1, 3; DX 3554D; DX 9405, pp. 174, 178, 1055, 1059; DX 14297.)

(viii) The speed of computer output printing has been increased by a factor of more than 130 from the IBM 716 printer in 1957 to the IBM 3800 laser printer announced in 1975 and enhanced in 1976, for only about a 4.0 times purchase price increase. (PX 4714, p. 3; DX 9405, pp. 121-22, 128, 479-80; Plaintiff's Admissions, Set II, ¶ 931.1.)

And Withington testified that the state of technological innovation in the general purpose computer business today is "at least as rapid today as at any period in the past". (Tr. 112946.)

Newer technologies, with new potentials, are being worked on by computer equipment manufacturers throughout the world. Those technologies include "Josephson" technology, in development at IBM and elsewhere (Gomory, Tr. 98248-64, 98268-73; E. Bloch, Tr. 92409-12, 93429-39); optical fiber technology for data transmission (Gomory, Tr. 98294-96); and speech recognition technologies, being developed by IBM, the Japanese and others. (Gomory, Tr. 98299-05.)

What is important for the industry is that, as history has shown us, no single manufacturer can control or manage the technology. The pattern of new announcements which we have discussed earlier illustrates the rapid diffusion of technological improvements. That in turn has an impact on all industry participants. Winston Hindle of Digital Equipment Corporation told a group of DEC's computer users in 1970:

> "There is no looking backward in our industry, as you undoubtedly know. So if one stops to ponder the past and be self-satisfied, the more aggressive competitors will quickly charge past." (DX 517, p. 2.)*

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* Hindle believed that statement was still accurate with respect to the computer business in 1975. (Tr. 7447-48.)

Burroughs' management, in its 1977 Annual Report, made a similar observation:

> "Advancing technology and changing market demand have led to new products that are significantly more powerful and cost effective. Dramatic new applications of these products are creating expanded market opportunities.
>
> "A major result of this rapid and far-reaching change is that the industry has become increasingly competitive. Additional companies in the United States have entered the market, and organizations outside the U.S. have emerged as significant factors. A series of major price reductions during 1977 generated additional competitive pressure." (DX 12289, p. 9.)

In 1979, near the close of the decade, the "U.S. Industrial Outlook" for the computer industry, published by the Department of Commerce (DX 12261), noted some of the developments which we have found to be significant and discussed in our testimony:

> "Japanese firms have recently entered the U.S. computer market . . . with a variety of products.
>
> * * *
>
> "Development of distributed computing capability, moving away from the total dependence on large central processing units has been aided by introductions of new terminals with data storage and processing capability, small computers, and communications-oriented software.
>
> "As a result of a growing integration of computers and communications, the convergence and potential conflict between the largely government regulated electronics communication industry and the non-regulated computer industry increases." (Id., p. 2.)

The report concludes with a prediction about the near future with which we concur:

> "The outlook through 1983 assumes intensified competition in virtually all sectors of the industry, backed by both the impetus of improved Very Large Scale Integration (VLSI) components and the aggressive pricing actions of firms seeking

market entry and expansion incorporating these components. Foreign firms, particularly Japanese, will be more visible in U.S. and foreign computer markets, having gained shares in an expanding market at the expense of U.S. firms." (*Id.*, p. 4.)